OMB Number: 4040-0001
Expiration Date: 10/31/2019

APPLICATION FOR FEDERAL ASSISTANCE

SF 424 (R&R)

3. DATE RECEIVED BY STATE	State Application Identifier

1. TYPE OF SUBMISSION

☐ Pre-application ☒ Application ☐ Changed/Corrected Application

2. DATE SUBMITTED: 02/20/2018

Applicant Identifier:

4. a. Federal Identifier: N00014

b. Agency Routing Identifier: 332 [Anderson, Michele]

c. Previous Grants.gov Tracking ID:

5. APPLICANT INFORMATION

Organizational DUNS: 009095365

Legal Name: University of Utah

Department: Division:

Street1: 75 South 2000 East

Street2:

City: Salt Lake City County / Parish: Salt Lake

State: UT: Utah Province:

Country: USA: UNITED STATES ZIP / Postal Code: 84112-8930

Person to be contacted on matters involving this application

Prefix: First Name: JENNIFER Middle Name:

Last Name: HOSKINS Suffix:

Position/Title: Contracts Administrator

Street1: 75 S 2000 E RM 215

Street2:

City: SALT LAKE CITY County / Parish: SALT LAKE

State: UT: Utah Province:

Country: USA: UNITED STATES ZIP / Postal Code: 84112-8930

Phone Number: 801-581-3005 Fax Number: 801-581-3005

Email: jennifer.hoskins@osp.utah.edu

6. EMPLOYER IDENTIFICATION *(EIN) or (TIN)*: 876000525

7. TYPE OF APPLICANT: H: Public/State Controlled Institution of Higher Education

Other (Specify):

Small Business Organization Type ☐ Women Owned ☐ Socially and Economically Disadvantaged

8. TYPE OF APPLICATION:

☒ New ☐ Resubmission

☐ Renewal ☐ Continuation ☐ Revision

If Revision, mark appropriate box(es).

☐ A. Increase Award ☐ B. Decrease Award ☐ C. Increase Duration ☐ D. Decrease Duration

☐ E. Other (specify):

Is this application being submitted to other agencies? Yes ☐ No ☒ What other Agencies?

9. NAME OF FEDERAL AGENCY: Office of Naval Research

10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER: 12.300

TITLE: Basic and Applied Scientific Research

11. DESCRIPTIVE TITLE OF APPLICANT'S PROJECT:

Continuous-time Cyber-Physical Control, Health Assessment and Resilient Response for Microgrids

12. PROPOSED PROJECT:

Start Date: 07/01/2018 Ending Date: 06/30/2021

13. CONGRESSIONAL DISTRICT OF APPLICANT: UT-002

14. PROJECT DIRECTOR/PRINCIPAL INVESTIGATOR CONTACT INFORMATION

Prefix: Dr. First Name: Masood Middle Name:
Last Name: Parvania Suffix:
Position/Title: Assistant Professor
Organization Name: University of Utah
Department: Electrical and Computer Eng Division:
Street1: 50 S Central Campus Drive, Room 2110
Street2:
City: Salt Lake City County / Parish: Salt Lake
State: UT: Utah Province:
Country: USA: UNITED STATES ZIP / Postal Code: 84112-8930
Phone Number: 8015850030 Fax Number:
Email: masood.parvania@utah.edu

15. ESTIMATED PROJECT FUNDING

a. Total Federal Funds Requested	1,998,185.00
b. Total Non-Federal Funds	0.00
c. Total Federal & Non-Federal Funds	1,998,185.00
d. Estimated Program Income	0.00

16. IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?

a. YES ☐ THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON:
DATE:

b. NO ☒ PROGRAM IS NOT COVERED BY E.O. 12372; OR
☐ PROGRAM HAS NOT BEEN SELECTED BY STATE FOR REVIEW

17. By signing this application, I certify (1) to the statements contained in the list of certifications* and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances * and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious. or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 18, Section 1001)

☒ **I agree**

The list of certifications and assurances, or an Internet site where you may obtain this list, is contained in the announcement or agency specific instructions.

18. SFLLL (Disclosure of Lobbying Activities) or other Explanatory Documentation

Add Attachment | Delete Attachment | View Attachment

19. Authorized Representative

Prefix: First Name: Brent Middle Name:
Last Name: Brown Suffix:
Position/Title: Director
Organization: University of Utah
Department: OFFICE OF SPONSORED PROJECTS Division: VP FOR RESEARCH
Street1: 75 South 2000 East
Street2:
City: Salt Lake City County / Parish: Salt Lake
State: UT: Utah Province:
Country: USA: UNITED STATES ZIP / Postal Code: 84112-8930
Phone Number: 801-581-6903 Fax Number: 801-585-5749
Email: ospawards@osp.utah.edu

Signature of Authorized Representative: Brent Brown

Date Signed: 02/20/2018

20. Pre-application Add Attachment | Delete Attachment | View Attachment

21. Cover Letter Attachment Add Attachment | Delete Attachment | View Attachment

ANGELA RASMUSSEN

ASSOCIATE PROFESSOR (LECTURER)
Electrical and Computer Engineering, University of Utah
50 S. Central Campus Dr., Rm. 2266B
Salt Lake City, UT 84112
Phone: (801) 581-6952 Fax: (801) 581-5281
EMAIL: Angela.Rasmussen@utah.edu

EDUCATION

D.Sc. Microelectronics and VLSI Systems, May 2002
Minors in Fluid Mechanics and Communications, THE GEORGE WASHINGTON UNIVERSITY, WASHINGTON D.C.

B.SC. in Computer Engineering, *Summa cum laude*, Graduated as top student, May 1996
THE GEORGE WASHINGTON UNIVERSITY, WASHINGTON D.C.

EXPERIENCE

DIRECTOR OF ADVISING AND MENTORING/ASSOCIATE PROFESSOR:

Electrical and Computer Engineering, University of Utah (Jan. 2004-present)

- Director of Mentoring and Advising (2015-present)
  - Directly supervise 2 individuals to provide all undergraduate and graduate advising.
  - Implement new programs for recruitment and retention.
  - Develop software for advising activities.
- Highly involved with ABET Accreditation (Fall 2015)
  - Worked closely with department chair and Dr. Cotter to gather all information and develop documentation
- Reorganized structure for EE Senior Projects
  - Created milestone driven tasks to push students to complete work on time
  - Supervise all communication work for all projects which includes new demo presentations
  - Organize all logistics for technical advising of all projects
- Created and supervised new ECE Student Project Expo (Spring 2017)
- Supervisor for individual and group senior theses, (2007-present)
  - Supervising 57 students, Fall 2017-Spring 2018
  - Supervised 333 students in independent or group projects between Fall 2007-Spring 2017
  - Supervisor of 2006 Best Senior Project Award, ("ASIC B-directional Level Shifter")
- Improved and taught classes in Electrical and Computer Engineering
  - Reorganized senior projects to have consistency while maintaining a high level of work.
  - Improved course content for ECE2280 by adding progressive project that requires the use of computer simulation tools (PSpice and Matlab) along with extending it to a built prototype.
  - Worked with two other professors to improve the content within ECE1250.
  - Co-taught ECE5201 – prepared example problems, exams, along with lecture material.
  - Updated course content for ECE2280 and ECE1270/1250 including "fill in the notes", in class active learning activities, and videos containing examples and methodologies.
  - Incorporated improvement comments from industry and students into course material for ECE2280.
  - Developed new course – Introduction to Semiconductor Physics (taught as Junior Seminar).
  - Worked with faculty to improve laboratory experiments for Introduction to Electrical Engineering course.
- Committee Chair for 9 graduate students. Participated on graduate committees for 4 other students.
- Performed service as scholarship committee chair (2011-present).

EDITOR/CONSULTANT:

McGraw-Hill (Fall 2014-present)

- Provide support and editing of all feedback received for Microelectronic Circuit by Richard Jaeger.
- Created learning objectives for 19 chapters of 5th edition, Microelectronic Circuit by Richard Jaeger.
- Editing online interactive software for assessments of learning objective as supplemental material.

Oxford University Press (Fall 2011-Fall 2013)

- Edited 13 chapters of new 6th edition of Microelectronic Circuits by Sedra/Smith.
- Created unique problems and solutions for 13 chapters published in a new supplemental problems booklet that accompanies the new 6th edition of Microelectronic Circuits by Sedra/Smith.

McGraw-Hill (Fall 2008-Spring 2009)

- Critically reviewed Fundamentals of Electrical Engineering by Rizzoni.

ASSISTANT PROFESSOR:
San Diego State University (Fall 2002-Summer 2003)

- Received outstanding teacher of the year award from the College of Engineering
- Taught Electrical and Computer Engineering core course. Restructured course to include electronic notes for the students. Received outstanding reviews from students.
- Aided in developing proposal for new bioengineering MS program. Wrote proposal for a new MEMS graduate course for this program.
- Applied and was funded for several grants.
- Served on the following committees: Undergraduate Curriculum Committee, Scholarships and Awards, Secretary to the Faculty, Faculty Book Chairperson, and Library Committee. Performed all duties associated with assistant professor of Electrical and Computer Engineering.

RESEARCH AND DEVELOPMENT:
Northrop Grumman – Ryan Aeronautical Center (MALD/MALI PROJECT) (7/00-1/02)

VISITING INSTRUCTOR:
Washington State University (Fall '98)

AWARDS

- Outstanding Service Award from the ECE Department, August 2015 (University of Utah)
- Outstanding ECE Teaching Award from the ECE Department, August 2013 (University of Utah)
- Outstanding Teacher of the Year Award from the College of Engineering, May 2003 (San Diego State)
- Dean's Fellowship *(full tuition and stipend)* awarded for outstanding academic achievement – 1996 to 1998
- Two money awards *(ITEA Scholarship and Hekimian Award)* for outstanding graduate research
- B.C. Cruickshanks award for graduating #1 in Computer Engineering class – May 1996

SELECTED PUBLICATIONS

A. Rasmussen, C. Mavriplis, M.E. Zaghloul, O. Mikulchenko, K. Mayaram, "Simulation and Optimization of Microfluidic Flow Sensors," *Sensors and Actuators A,* vol. 88, issue 2, Feb. 2001, pp. 121-132.

A. Rasmussen, M. Gaitan, L.E. Locascio, M.E. Zaghloul, "Fabrication Techniques to Realize CMOS-compatible Microfluidic Microchannels," *IEEE JMEMS,* June 2001, pp. 286 –297.

O. Mikulchenko, A. Rasmussen, K. Mayaram, "A Neural Network Based Macromodel for Microflow Sensors," *Proc. Of 3rd Int. Conf. On Modeling and Simulation of Microsystems*, San Diego, CA, March 27-29, 2000

A. Rasmussen and M.E. Zaghloul, "Pumping Techniques Available for use in Biomedical Analysis Systems," and "CMOS Microfluidic Fabrication Technology for Biomedical Applications," *Midwest Symposium on Circuits and Systems*, August 1999, pp. 656 -659 and pp. 791 -794 vol. 2.

A. Rasmussen and M.E. Zaghloul, "The Design and Fabrication of Microfluidic Flow Sensors," *ISCAS '99,* June 1-3, 1999, pp. 136-139, vol. 5.

L. Sellami, S. K. Singh, R. W. Newcomb, A. Rasmussen, and M. E. Zaghloul, "VLSI Floating Resistors for Neural Type Cell Arrays," The International Journal of Circuits, Systems, and Computers, accepted for publication April 1999

A. Rasmussen, L.E. Locascio, M. Gaitan, and M.E. Zaghloul, "Utilization of standard CMOS layers for microchannels," *ASME Int. Mechanical Engineering Congress and Exposition (IMECE'98)*, MEMS November 1998, DSC-Vol. 66, pp. 407-411

A. Rasmussen and M.E. Zaghloul, "In the Flow with MEMS: Translating the Physical to Electrical with Flow Sensors Based on Microelectromechanical Systems," *IEEE Circuits and Devices Magazine*, July 1998, vol. 14, no. 4, pp. 12-25.

A. Rasmussen and M.E. Zaghloul, "CMOS analog implementation of cellular neural network to solve partial differential equations with a microelectromechanical thermal interface," *40th Midwest Symposium on Circuits and Systems*, Sacramento, CA, Aug. 3-6, 1997, pp. 1326-1329

L. Sellami, S. K. Singh, R. W. Newcomb, A. Rasmussen, and M. E. Zaghloul, "CMOS Bilateral Floating Linear Resistor for Neural-Type Cell Arrays," Proceedings of the Asilomar Conference on Circuits, Systems, and Computers, pp. 1136-1140, Pacific Grove, CA, Nov. 3-6, 1997

Dean Gallagher

Technology Licensing Manager – University of Utah - TVC

Dean Gallagher has over 30 years of experience in the project management, engineering, construction, and operation of complex projects involving power systems, telecommunication networks, and engineering software development.

Experience

University of Utah
Salt Lake City, Utah, 2017–Present

Dean Gallagher is a Technology Licensing Manager with Technology and Ventures Commercialization (TVC) responsible for managing the assessment, marketing and protection of intellectual property created at the University of Utah and assists in the management of the Technology Commercialization operations.

Schweitzer Engineering Laboratories, Inc.
King of Prussia, Pennsylvania, 2015–2017

Dean was an Engineering Project manager at Schweitzer Engineering Laboratories, Inc. (SEL) managing Substation Control Enclosures engineering and design projects including integrated relay panels, cabling, testing, and commissioning. Dean's additional responsibilities include developing design and project management standards.

Bentley Systems
Exton, Pennsylvania, 2012–2015

Dean was a project manager in the development and implementation of enterprise systems, from proposal through acceptance and close-out. These systems consisted of asset management, Geographic Information System, Linear Referencing Systems, power substations, telecommunications, and document management for utility, state transportation, and industrial customers.

Rumsey Electric – Relay & Power Systems
Conshohocken, Pennsylvania, 2011–2012

Dean was a project manager for power substation projects, from proposal and award through fabrication and testing. Projects he managed included power substation relay panels, control houses, power houses, and major electrical equipment for utility and industrial customers.

Areva T&D/Alstom Grid/GE
Philadelphia, Pennsylvania, 2009–2011

Dean was a project manager for international power substation Flexible Alternating Current Transmission Systems (FACTS) projects, from inception through commissioning. Manage the design and manufacturing of Static VAR Compensator and Fixed Series Capacitors projects for utility and industrial customers.

Sunesys/Quanta Services/Crown Castle
Warrington, Pennsylvania, 2005–2009

Dean was a project and operations manager for the engineering and construction of fiber-optic networks during a period of rapid growth. He developed and grew a staff of project managers, engineers, and designers. He supported the engineering, design, build-out, and documentation of over 1,000 route-miles of newly constructed network with 750 buildings in over seven states during a two-year period. He also implemented an AutoCAD and Oracle GIS enterprise system to track infrastructure and documentation.

Power Measurement/Schneider Electric
Philadelphia, Pennsylvania, 2004–2005

Dean was a project manager in the development and deployment of ION enterprise solutions for monitoring ION smart power meters. The projects Dean managed included large campus distribution systems, refineries, industrial, and commercial installations.

PECO Energy
Philadelphia, Pennsylvania, 1987–2003

Dean began as a substation field engineer and progressed to substation project engineer, distribution network engineer, and project manager. As a field engineer, Dean tested and commissioned power substation projects, including transformers, circuit breakers, switchgear, control houses, transmission lines, and SCADA. He also developed and executed test plans, trip testing, and outage planning and investigated equipment failures. Dean progressed to project engineer and team leader for power substation projects, including the installation of power transformers, circuit breakers, switchgear, relay protection, control schemes, and SCADA. In addition, Dean was a network engineer managing power distribution projects to provide electric service to residential, commercial, and industrial customers. In the telecommunications group, Dean managed the design and construction of a 1,200 mile fiber-optic SONET network. He was also responsible for the day-to-day operation and maintenance of all fiber-optic facilities.

Education:

BS Electrical and Computer Engineering, Drexel University, Philadelphia, Pennsylvania, 1987

PMP (PMI), 1994

Affiliations:

IEEE, Member

PMI, Member

Sneha Kumar Kasera

Professional Preparation

- St. Xavier's College, Calcutta, Physics Honors, B.S. 1986
- Indian Institute of Science, Bangalore, Electrical and Communication Eng., M.S. 1990
- University of Massachusetts Amherst, Computer Science, PhD 1999

Appointments

- July 2015 - current, Professor, School of Computing, University of Utah
- July 2009 - June 2015, Associate Professor, School of Computing, University of Utah
- July 2003 - June 2009, Assistant Professor, School of Computing, University of Utah
- September 1999–July 2003, Member of Technical Staff, Mobile Networking Research Department, Bell Labs Research, Lucent Technologies
- January-May 2003, Adjunct Faculty, Electrical and Computer Engineering, Polytechnic University, New York
- 1993–1999, Research Assistant, University of Massachusetts Amherst
- Summer 1994, Intern in Broadband Networking Group, IBM T.J. Watson Research Center, New York
- Summer 1995, Intern in Computer Network Research Department, AT&T Bell Labs, New Jersey
- 1991-1992, Member of Technical Staff, Center for Development of Advanced Computing, India
- 1990–1991, R & D Engineer, Wipro Infotech Limited, India

Related/Selected Publications

1. M. Khaledi, M. Khaledi, and S.K. Kasera, "*Simultaneous Power-Based Localization of Transmitters for Crowdsourced Spectrum Monitoring*," in Proc. of ACM MobiCom Conference, October 2017. http://ansr.cs.utah.edu/spectrum-offenders/
2. A. Banerjee, R. Mahindra, K. Sundresan, Sneha Kumar Kasera, K. Van der Merwe, and S. Rangarajan, "*Scaling the LTE Control-Plane for Future Mobile Access*," in Proceedings of ACM CoNEXT, December 2015. http://dl.acm.org/citation.cfm?id=2836104
3. A. Banerjee, D. Maas, M. Bocca, N. Patwari, S.K. Kasera, "*Violating Privacy Through Walls by Passively Monitoring Radio Windows*," in Proc. of the 7th ACM Conference on Security and Privacy in Wireless and Mobile Networks (WiSec), July 2014. http://dl.acm.org/citation.cfm?doid=2627393.2627418
4. S. N. Premnath, J. Croft, N. Patwari, and Sneha K. Kasera, "*Efficient High Rate Secret Key Extraction in Wireless Sensor Networks Using Collaboration*," in ACM Transactions on Sensor Networks, vol. 11, no. 1, August 2014.
5. S.N. Premnath, D. Wasden, S.K. Kasera, N. Patwari, B. Farhang-Boroujeny, "*Beyond OFDM: Best Effort Dynamic Spectrum Access Using Filterbank Multicarrier*," in IEEE/ACM Transactions on Networking, vol. 21, no. 3, pages 869-882, June 2013. http://dl.acm.org/citation.cfm?id=2525557

6. S. N. Premnath, S. Jana, J. Croft, P. L. Gowda, M. Clark, S. K. Kasera, N. Patwari, S. V. Krishnamurthy, "*Secret Key Extraction from Wireless Signal Strength in Real Environments*," in IEEE Transactions on Mobile Computing, vol. 12, no. 5, 917-930, May 2013. An earlier version of this work appeared in Proc. of ACM MobiCom Conference, 2009. http://ieeexplore.ieee.org/document/6171198/
7. Junxing Zhang, S.K. Kasera, N. Patwari, and P. Rai, "*Distinguishing Locations Across Perimeters Using Wireless Link Measurements*," in Proc. of IEEE Infocom, April 2011. http://ieeexplore.ieee.org/document/5935162/
8. S. Jana and S.K. Kasera, "*On Fast and Accurate Detection of Unauthorized Access Points Using Clock Skews*," in IEEE Transactions on Mobile Computing, vol. 9, no. 3, pages 449-462, March 2010. An earlier version of this work appeared in Proc. of ACM MobiCom Conference, September 2008. http://ieeexplore.ieee.org/document/5210105/
9. J. Zhang, M.H. Firooz, N. Patwari, and Sneha K. Kasera, "*Advancing Link Signatures for Location Distinction*," in Proc. of ACM MobiCom Conference, September 2008. http://dl.acm.org/citation.cfm?id=1409944.1409949
10. N. Patwari and Sneha K. Kasera, "*Robust Location Distinction Using Temporal Link Signatures*," in Proc. of ACM MobiCom Conference, September 2007. http://dl.acm.org/citation.cfm?id=1287867

Synergistic Activities

- *Associate Editor*
  - IEEE Transactions on Mobile Computing (2011–2015),
  - IEEE/ACM Transactions on Networking (2009-2013),
  - ACM MC^{2}R (2008- 2009),
  - ACM/Springer WINET (2007-2011),
  - Elsevier Computer Networks (2005- 2009)
- *Program Co-Chair*
  - ACM WiSec 2017
  - ACM MobiCom 2015
  - IEEE ICNP 2011
  - IEEE SECON 2011
- *Computer Science Lead of the NSF funded STEP project* – "Utah's Engineers: A Statewide Initiative for Growth," worked with undergraduate students to develop high school educational modules that demonstrate the use of high school math and science concepts in Computer Science.
- *Robust Overload Control* – Variants of my overload control algorithms, developed while at Bell Labs, were deployed in Lucent products.
- *Technical Program Committee* (recent)
  2018 – ACM MobiCom, ACM WiSec
  2017 – ACM MobiCom
  2016 – ACM MobiCom, ACM WiSec, ACM MobiHoc
  2015 – ACM MobiCom, ACM WiSec
  2014 – ACM MobiHoc, IEEE Secon (Area Chair), Comsnets
  2013 – ACM MobiCom

Current and Pending Project and Proposal Submissions
Angela Rasmussen

N/A

Current and Pending Project and Proposal Submissions
Dean Gallagher

N/A

Current and Pending Project and Proposal Submissions
Sneha Kumar Kasera

Support: ☒ Current ☐ Pending

Proposal Title: Prisms Informatics Platform - Federated Integration Architecture - Data Acquisition

Proposal Summary: Development of processes and tools for collection of sensor data (e.g., air quality data) for research related to human health.

Source of support: NIH

Total Award Amount: $5,529,663 Period of Performance: 09/2015 - 09/2019

Prime applicant and list of subawards: University of Utah

Technical Contact: Sneha Kumar Kasera Business/Administrative Contact:

Person-Months Per Year Committed to the Project 0.75 (average per year only for last two years)

Relation to and overlap with this proposal: Develop security and privacy solutions for IoT data acquisition.

Support: ☒ Current ☐ Pending

Proposal Title: NeTS: Medium: Detecting and Localizing Spectrum Offenders Using Crowdsourcing

Proposal Summary: Building a novel approach that crowdsources the detection and localization of spectrum offenders to a distributed set of wireless devices over space, time, and frequency.

Source of support: NSF

Total Award Amount: $951,970 Period of Performance: 08/2016 - 07/2019

Prime applicant and list of subawards: University of Utah

Technical Contact: Sneha Kumar Kasera Business/Administrative Contact:

Person-Months Per Year Committed to the Project 1.5

Relation to and overlap with this proposal: Distributed detection and localization of unauthorized actions.

Support: ☒ Current ☐ Pending

Proposal Title: NeTS: Medium: KnowOps - Making Network Management and Operations Software

Proposal Summary: Development of knowledge-centric software defined network management and operation architecture.

Source of support: NSF

Total Award Amount: $1,140,746 Period of Performance: 10/2013 - 09/2018

Prime applicant and list of subawards: University of Utah

Technical Contact: Sneha Kumar Kasera Business/Administrative Contact:

Person-Months Per Year Committed to the Project 1.0 (for the first three years)

Relation to and overlap with this proposal: Auto-tuned resource management methods for robustness.

Support: ☒ Current ☐ Pending

Proposal Title: Edge Intelligence for Virtualization and Security in Open Networks

Proposal Summary: Development of a software platform to enable Open Networks so that services reside in dedicated virtual channels.

Source of support: DOE

Total Award Amount: $303,921 Period of Performance: 04/2016 - 04/2018

Prime applicant and list of subawards: University of Utah

Technical Contact: Sneha Kumar Kasera Business/Administrative Contact:

Person-Months Per Year Committed to the Project 0.5

Relation to and overlap with this proposal: Privacy-preserving smart services.

Support: ☒ Current ☐ Pending

Proposal Title: Radio Frequency Spectrum Analysis

Proposal Summary: Developing wireless signal classification techniques for practical and real-time spectrum monitoring

Source of support: Idaho National Lab

Total Award Amount: $225,923 Period of Performance: 01/2016 - 09/2018

Prime applicant and list of subawards: University of Utah

Technical Contact: Sneha Kumar Kasera Business/Administrative Contact:
Person-Months Per Year Committed to the Project 0.5 (first two years), 0.6 (current year)
Relation to and overlap with this proposal: Real-time detection and classification of unknown behavior.

Support: ☒ Current ☐ Pending
Proposal Title: Preventing Radio Window Attacks
Proposal Summary: Development of methods for protecting privacy of moving humans, objects as they disturb the radio field (RF) around them that can be measured by an adversary.
Source of support: Army Research Office
Total Award Amount: $395,000 Period of Performance: 06/2017 - 06/2020
Prime applicant and list of subawards: University of Utah
Technical Contact: Sneha Kumar Kasera Business/Administrative Contact:
Person-Months Per Year Committed to the Project 0.5
Relation to and overlap with this proposal: Understand RF patterns and develop methods to hide them.

Support: ☐ Current ☒ Pending
Proposal Title: POWDER: Platform for Open Wireless Data-driven Experimental Research
Proposal Summary: Development and deployment of a remotely accessible, wireless testbed in Salt Lake City for experimental wireless research.
Source of support: PAWR Project Office
Total Award Amount: $12,461,908 Period of Performance: 04/2018 - 04/2023
Prime applicant and list of subawards: University of Utah
Technical Contact: Sneha Kumar Kasera Business/Administrative Contact:
Person-Months Per Year Committed to the Project 0.8 months (average per year)
Relation to and overlap with this proposal: Opportunity to shape, access a major testbed, as necessary.

Support: ☐ Current ☒ Pending
Proposal Title: (b) (4) [redacted]
Proposal Summary: (b) (4) [redacted]
Source of support: (b) [redacted]
Total Award Amount: (b) (4) [redacted] Period of Performance: 07/2018 - 06/2022
Prime applicant and list of subawards: University of Utah
Technical Contact: Sneha Kumar Kasera Business/Administrative Contact:
Person-Months Per Year Committed to the Project 0.75
Relation to and overlap with this proposal: (b) (4) [redacted]

Support: ☐ Current ☒ Pending
Proposal Title: SpecEES: Dynamic Space Frequency Multiplexing - A New Paradigm for Filterbank MC
Proposal Summary: Development of a unique cross-layer approach for broadband spectrum access to significantly improve both spectral and energy efficiency.
Source of support: NSF
Total Award Amount: $749,892 Period of Performance: 08/2018 - 07/2021
Prime applicant and list of subawards: University of Utah
Technical Contact: Sneha Kumar Kasera Business/Administrative Contact:
Person-Months Per Year Committed to the Project 0.5
Relation to and overlap with this proposal: Cross-layer solutions, utility and resource tradeoffs.

Check Form for Errors | Save

RESEARCH & RELATED BUDGET - Budget Period 1

OMB Number: 4040-0001
Expiration Date: 10/31/2019

ORGANIZATIONAL DUNS: 0399563340000 **Enter name of Organization:** Idaho National Laboratory

Budget Type: ☒ Project ☐ Subaward/Consortium **Budget Period: 1** **Start Date:** 03/01/2018 **End Date:** 09/30/2018

A. Senior/Key Person

Prefix	First	Middle	Last	Suffix	Base Salary ($)	Months Cal.	Months Acad.	Months Sum.	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
Dr.	Craig		Rieger						(b) (4)	(b) (4)	(b) (4)
Project Role:	PD/PI										
	Timothy		McJunkin						(b) (4)	(b) (4)	(b) (4)
Project Role:	Control and Power Systems Researcher										
	Justin		Cox						(b) (4)	(b) (4)	(b) (4)
Project Role:	Computer and Cyber Researcher										
Dr.	Milos		Manic						(b) (4)	(b) (4)	(b) (4)
Project Role:	Machine Learning and Decision Support										

Additional Senior Key Persons: Add Attachment | Delete Attachment | View Attachment

Total Funds requested for all Senior Key Persons in the attached file

Total Senior/Key Person (b) (4)

B. Other Personnel

Number of Personnel	Project Role	Months Cal.	Months Acad.	Months Sum.	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
2	Secretarial/Clerical				(b) (4)	(b) (4)	(b) (4)

2 **Total Number Other Personnel**

Total Other Personnel (b) (4)

Total Salary, Wages and Fringe Benefits (A+B) 98,088.72

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment item	Funds Requested ($)

Additional Equipment: Add Attachment | Delete Attachment | View Attachment

Total funds requested for all equipment listed in the attached file	
Total Equipment	

D. Travel

	Funds Requested ($)
1. Domestic Travel Costs (Incl. Canada, Mexico and U.S. Possessions)	8,058.40
2. Foreign Travel Costs	
Total Travel Cost	8,058.40

E. Participant/Trainee Support Costs

	Funds Requested ($)
1. Tuition/Fees/Health Insurance	
2. Stipends	
3. Travel	
4. Subsistence	
5. Other	
Number of Participants/Trainees / **Total Participant/Trainee Support Costs**	

F. Other Direct Costs

		Funds Requested ($)
1.	Materials and Supplies	28,204.40
2.	Publication Costs	
3.	Consultant Services	
4.	ADP/Computer Services	
5.	Subawards/Consortium/Contractual Costs	
6.	Equipment or Facility Rental/User Fees	
7.	Alterations and Renovations	
8.		
9.		
10.		
	Total Other Direct Costs	28,204.40

G. Direct Costs

	Funds Requested ($)
Total Direct Costs (A thru F)	134,351.52

H. Indirect Costs

Indirect Cost Type	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)
Common Support			(b) (4)
General and Administrative			(b) (4)
Laboratory Directed Research and Development			(b) (4)
Safeguards and Security			(b) (4)

Total Indirect Costs	42,814.39

Cognizant Federal Agency
(Agency Name, POC Name, and POC Phone Number)

INL, Arik Reynolds (208)526-1774

I. Total Direct and Indirect Costs

	Funds Requested ($)
Total Direct and Indirect Institutional Costs (G + H)	177,165.91

J. Fee

Funds Requested ($)
5,314.98

K. Total Costs and Fee

	Funds Requested ($)
Total Costs and Fee (I + J)	182,480.89

L. Budget Justification

(Only attach one file.)

INL budget-justification.pdf

Add Attachment | Delete Attachment | View Attachment

Check Form for Errors | Save

RESEARCH & RELATED BUDGET - Budget Period 2

OMB Number: 4040-0001
Expiration Date: 10/31/2019

ORGANIZATIONAL DUNS: 0399563340000 **Enter name of Organization:** Idaho National Laboratory

Budget Type: ☒ Project ☐ Subaward/Consortium **Budget Period: 2** **Start Date:** 10/01/2018 **End Date:** 09/30/2019

A. Senior/Key Person

Prefix	First	Middle	Last	Suffix	Base Salary ($)	Months Cal.	Months Acad.	Months Sum.	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
Dr.	Craig		Rieger						(b) (4)	(b) (4)	(b) (4)
Project Role:	PD/PI										
	Timothy		McJunkin						(b) (4)	(b) (4)	(b) (4)
Project Role:	Control and Power Systems Researcher										
	Justin		Cox						(b) (4)	(b) (4)	(b) (4)
Project Role:	Computer and Cyber Researcher										
Dr.	Milos		Manic						(b) (4)	(b) (4)	(b) (4)
Project Role:	Machine Learning and Decision Support										

Additional Senior Key Persons: Add Attachment | Delete Attachment | View Attachment

Total Funds requested for all Senior Key Persons in the attached file

Total Senior/Key Person (b) (4)

B. Other Personnel

Number of Personnel	Project Role	Months Cal.	Months Acad.	Months Sum.	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
2	Secretarial/Clerical				(b) (4)	(b) (4)	(b) (4)

2 **Total Number Other Personnel**

Total Other Personnel (b) (4)

Total Salary, Wages and Fringe Benefits (A+B) (b) (4)

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment item	Funds Requested ($)

Additional Equipment: Add Attachment | Delete Attachment | View Attachment

Total funds requested for all equipment listed in the attached file	
Total Equipment	

D. Travel

	Funds Requested ($)
1. Domestic Travel Costs (Incl. Canada, Mexico and U.S. Possessions)	8,224.00
2. Foreign Travel Costs	
Total Travel Cost	8,224.00

E. Participant/Trainee Support Costs

	Funds Requested ($)
1. Tuition/Fees/Health Insurance	
2. Stipends	
3. Travel	
4. Subsistence	
5. Other	
Number of Participants/Trainees / **Total Participant/Trainee Support Costs**	

F. Other Direct Costs

		Funds Requested ($)
1.	Materials and Supplies	5,756.80
2.	Publication Costs	
3.	Consultant Services	
4.	ADP/Computer Services	
5.	Subawards/Consortium/Contractual Costs	
6.	Equipment or Facility Rental/User Fees	
7.	Alterations and Renovations	
8.		
9.		
10.		
	Total Other Direct Costs	5,756.80

G. Direct Costs

	Funds Requested ($)
Total Direct Costs (A thru F)	126,950.62

H. Indirect Costs

Indirect Cost Type	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)
Common Support			(b) (4)
General and Administrative			(b) (4)
Laboratory Directed Research and Development			(b) (4)
Safeguards and Security			(b) (4)

Total Indirect Costs	58,656.91

Cognizant Federal Agency
(Agency Name, POC Name, and POC Phone Number)

INL, Arik Reynolds (208)526-1774

I. Total Direct and Indirect Costs

	Funds Requested ($)
Total Direct and Indirect Institutional Costs (G + H)	185,607.53

J. Fee

Funds Requested ($)
5,568.23

K. Total Costs and Fee

	Funds Requested ($)
Total Costs and Fee (I + J)	191,175.76

L. Budget Justification

(Only attach one file.)

INL budget-justification.pdf

Add Attachment | Delete Attachment | View Attachment

Check Form for Errors | Save

RESEARCH & RELATED BUDGET - Budget Period 3

OMB Number: 4040-0001
Expiration Date: 10/31/2019

ORGANIZATIONAL DUNS: 0399563340000 **Enter name of Organization:** Idaho National Laboratory

Budget Type: ☒ Project ☐ Subaward/Consortium **Budget Period: 3** **Start Date:** 10/01/2019 **End Date:** 09/30/2020

A. Senior/Key Person

Prefix	First	Middle	Last	Suffix	Base Salary ($)	Months Cal.	Months Acad.	Months Sum.	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
Dr.	Craig		Rieger						(b) (4)	(b) (4)	(b) (4)
Project Role:	PD/PI										
	Timothy		McJunkin						(b) (4)	(b) (4)	(b) (4)
Project Role:	Control and Power Systems Researcher										
	Justin		Cox						(b) (4)	(b) (4)	(b) (4)
Project Role:	Computer and Cyber Researcher										
Dr.	Milos		Manic						(b) (4)	(b) (4)	(b) (4)
Project Role:	Machine Learning and Decision Support										

Additional Senior Key Persons: Add Attachment | Delete Attachment | View Attachment

Total Funds requested for all Senior Key Persons in the attached file

Total Senior/Key Person (b) (4)

B. Other Personnel

Number of Personnel	Project Role	Months Cal.	Months Acad.	Months Sum.	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
2	Secretarial/Clerical				(b) (4)	(b) (4)	(b) (4)

2 **Total Number Other Personnel**

Total Other Personnel (b) (4)

Total Salary, Wages and Fringe Benefits (A+B) 94,512.98

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment item	Funds Requested ($)

Additional Equipment: Add Attachment | Delete Attachment | View Attachment

Total funds requested for all equipment listed in the attached file	
Total Equipment	

D. Travel

	Funds Requested ($)
1. Domestic Travel Costs (Incl. Canada, Mexico and U.S. Possessions)	8,386.40
2. Foreign Travel Costs	
Total Travel Cost	8,386.40

E. Participant/Trainee Support Costs

	Funds Requested ($)
1. Tuition/Fees/Health Insurance	
2. Stipends	
3. Travel	
4. Subsistence	
5. Other	
Number of Participants/Trainees / **Total Participant/Trainee Support Costs**	

F. Other Direct Costs

		Funds Requested ($)
1.	Materials and Supplies	5,870.48
2.	Publication Costs	
3.	Consultant Services	
4.	ADP/Computer Services	
5.	Subawards/Consortium/Contractual Costs	
6.	Equipment or Facility Rental/User Fees	
7.	Alterations and Renovations	
8.		
9.		
10.		
	Total Other Direct Costs	5,870.48

G. Direct Costs

	Funds Requested ($)
Total Direct Costs (A thru F)	108,769.86

H. Indirect Costs

Indirect Cost Type	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)
Common Support			(b) (4)
General and Administrative			(b) (4)
Laboratory Directed Research and Development			(b) (4)
Safeguards and Security			(b) (4)

Total Indirect Costs	48,562.80

Cognizant Federal Agency
(Agency Name, POC Name, and POC Phone Number)

INL, Arik Reynolds (208)526-1774

I. Total Direct and Indirect Costs

	Funds Requested ($)
Total Direct and Indirect Institutional Costs (G + H)	157,332.66

J. Fee

Funds Requested ($)
4,719.98

K. Total Costs and Fee

	Funds Requested ($)
Total Costs and Fee (I + J)	162,052.64

L. Budget Justification

(Only attach one file.)

INL budget-justification.pdf

Add Attachment | Delete Attachment | View Attachment

RESEARCH & RELATED BUDGET - Cumulative Budget

		Totals ($)
Section A, Senior/Key Person		(b) (4) [redacted]
Section B, Other Personnel		[redacted]
Total Number Other Personnel	6	
Total Salary, Wages and Fringe Benefits (A+B)		305,571.52
Section C, Equipment		
Section D, Travel		24,668.80
1. Domestic	24,668.80	
2. Foreign		
Section E, Participant/Trainee Support Costs		
1. Tuition/Fees/Health Insurance		
2. Stipends		
3. Travel		
4. Subsistence		
5. Other		
6. Number of Participants/Trainees		
Section F, Other Direct Costs		39,831.68
1. Materials and Supplies	39,831.68	
2. Publication Costs		
3. Consultant Services		
4. ADP/Computer Services		
5. Subawards/Consortium/Contractual Costs		
6. Equipment or Facility Rental/User Fees		
7. Alterations and Renovations		
8. Other 1		
9. Other 2		
10. Other 3		
Section G, Direct Costs (A thru F)		370,072.00
Section H, Indirect Costs		150,034.10
Section I, Total Direct and Indirect Costs (G + H)		520,106.10
Section J, Fee		15,603.19
Section K, Total Costs and Fee (I + J)		(b) (4) [redacted]

Budget Justification

A. Key Personnel (Includes PI and Co-PI/s)

- Dr. Craig Rieger: Craig is the co-PI for this effort from INL. Craig has developed a grand challenge and pioneered the research field of resilient control systems, including a interdisciplinary team of cyber security, control engineering, cognitive psychology and domain specific subject matter experts. Craig founded and has been the general chair for 10 IEEE technical co-sponsored Resilience Week (and predecessor) symposia and the NSF-sponsored National Workshop on Resilience Research. Craig has been both a research and practitioner in the area of control systems, and has a keen understanding of transition research to commercial applications. Craig Rieger has a PhD in Measurements and Control Engineering from Idaho State University, is a directorate fellow and chief control systems research engineer at INL.
- Mr. Tim McJunkin, control and power systems researcher will be developing resilient control algorithms for benchmarking system performance for the ARR and defining scenarios for evaluating benefit. This effort includes definition of function requirements when enacting ARR responses in the microgrid test environment. Tim will also develop power and control system models that will be used in the microgrid Test Environment. Tim has extensive experience in the development of resilience metrics tools specific to distribution systems, fusion of cyber and physical information, robotics design and application. Tim has an MS in Electrical Engineering from Utah State University.
- Dr. Milos Manic, machine learning and decision support, will support the development of resilience metrics and ARR algorithms using fuzzy-neural and computational intelligence methods. Milos will support the leveraging of the existing methodologies built into AICS in working with the University of Utah project team and Justin extend AICS to cyber and cyber-physical anomaly detection techniques. Milos has extensive experience in computational intelligence and its application to cyber-physical applications in the energy domain. Milos has more than 2000 citations and 200 publications in this area. Milos has a PhD in Computer Science and is a joint appointee to INL.
- Mr. Justin Cox, computer and cyber researcher, will be supporting the development of ARR response and characterizing changes within the microgrid control system architecture. Justin is the part of the AICS development team, and will be engaging with the University of Utah Project team on leveraging AICS for enhancement to include AHA physical and cyber-physical integration of technical. Justin is part of the cyber research team at INL, and has been involved in the reverse engineering, forensics and vulnerability assessment efforts, in addition to development of new cyber threat and response tools. be Justin has a MS in Computer Engineering from Utah State University.

C. Fringe Benefits and Indirect Rates

See attached rates memo for INL.

D. Equipment

INL has an existing diverse control system environment that incorporates high fidelity modeling capabilities. However, an additional server and licensing to extend the emulation capabilities in OpalRT will be purchased to allow for additional scale application for evaluating multiple

interconnected microgrids to allow for a TRL5-6 scaling that confirms maturity of the developed technologies in larger, more diverse environments.

E. Travel

Travel for this effort is based upon 2 personnel traveling twice per year of this effort. Each trip will be approximately 3 days with a cost of $1000 for airfare and $1000 for hotel and per diem per person. It us expected that one trip per year will be associated with a PI meeting and the second to attend a conference, which could include Resilience Week, the PES General Meeting or CPS Week.

Attached Rates

	Year 1	Year 2	Year 3	Total
Dr. Craig Rieger	$ (b) (4)	$ (b) (4)	$ (b) (4)	$ (b) (4)
Mr. Tim McJunkin	$	$	$	$
Dr. Milos Manic	$	$	$	$
Mr. Justin Cox	$	$	$	$
Other Personnel	$	$	$	$
Travel	$ 8,058	$ 8,224	$ 8,386	$ 24,669
Materials	$ 28,204	$ 5,757	$ 5,870	$ 39,832
Company Adders				
Common Support	$ 14,495	$ 20,754	$ 16,947	$ 52,196
G&A	$ 20,127	$ 27,943	$ 23,259	$ 71,328
LDRD	$ 4,152	$ 4,350	$ 3,687	$ 12,190
S&S	$ 4,041	$ 5,610	$ 4,669	$ 14,320
FAC	$ 5,315	$ 5,568	$ 4,720	$ 15,603
TOTAL	**$ 182,481**	**$ 191,176**	**$ 162,053**	**$ 535,709**

CRAIG G. RIEGER
Chief Control Systems Research Engineer
Work: (208) 526-4136 Cell: (208) 851-8839 FAX (208)526-2190
Craig.Rieger@inl.gov

PROFESSIONAL PREPARATION

Institution	Location	Major	Degree	Year
Montana State University	*Bozeman, MT*	*ChE*	*BS*	*1983*
Montana State University	*Bozeman, MT*	*ChE*	*MS*	*1985*
Idaho State University	*Pocatello, ID*	*EAS*	*PhD*	*2008*

RESEARCH AND PROFESSIONAL EXPERIENCE

- Chief Control Systems Research Engineer, responsible for control system centric research initiatives, Idaho National Laboratory (INL) INL, 2015-Present
- Instrumentation, Control and Intelligent Systems Research Lead, INL, responsible for interdisciplinary initiative on resilient control systems, INL, 2007-2015
- Control System and Power Engineering Department Manager, resource manager for power and control system engineers supporting security projects, INL, 2006-2007
- Supervisor and Process Control Engineer, control system group resource management and control engineer for a subset of facilities, INL, 1994-2005
- Process Control Engineer, responsible for design, configuration and maintaining a subset of process control systems, INL, 1988-1994

SELECT PUBLICATIONS

- T. McJunkin, C. Rieger, "Electricity Distribution System Resilient Control System Metrics," *in Resilience Week (RWS) 2017*, 2017.
- M. Manic, K. Amarasinghe, J. J. Rodriguez-Andina and C. Rieger, "Intelligent Buildings of the Future: Cyberaware, Deep Learning Powered, and Human Interacting," in *IEEE Industrial Electronics Magazine*, vol. 10, no. 4, pp. 32-49, Dec. 2016.
- K. Eshghi, B. K. Johnson and C. G. Rieger, "Power system protection and resilient metrics," *2015 Resilience Week*, Philadelphia, PA, 2015, pp. 1-8.
- C. Rieger, "Resilient Control Systems: Practical Metrics Basis for Defining Mission Impact," 7th International Symposium on Resilient Control Systems, August, 2014.
- D. Wijayasekara, O. Linda, M. Manic, C. Rieger, "Mining Building Energy Management System Data Using Fuzzy Anomaly Detection and Linguistic Descriptions," IEEE Transactions on Industrial Informatics, August 2014.
- D. Wijayasekara, O. Linda, M. Manic, C. Rieger, "FN-DFE: Fuzzy-Neural Data Fusion Engine for Enhanced Resilient State-Awareness of Hybrid Energy Systems," Special Issue on Resilient Architectures and Systems, IEEE Transactions on Cybernetics, November 2014.
- C. G. Rieger, K.L. Moore, T.L. Baldwin, "Resilient Control Systems: A Multi-Agent Dynamic Systems Perspective," International Conference on Electro/Information Technology, May 2013.
- C. Rieger, Q. Zhu, "A Hierarchical Multi-Agent Dynamical System Architecture for Resilient Control Systems," 6th International Symposium on Resilient Control Systems, August, 2013.
- Q. Zhu, C. Rieger, T. Basar, "A hierarchical security architecture for cyber-physical systems," 4th International Symposium on Resilient Control Systems, vol., no., pp.15-20, August 2011.
- C. G. Rieger, "Notional Examples and Benchmark Aspects of a Resilient Control System, 3rdInternational Symposium on Resilient Control Systems, August 2010.
- C. G. Rieger, D. I. Gertman, and M. A. McQueen, "Resilient Control Systems: Next Generation Design Research", 2nd Conference on Human System Interactions, pp. 632 – 636, May 2009.

SYNERGISTIC ACTIVITIES

- Started remote Fall course for Idaho research university undergraduates and graduates to overview the interdisciplinary science and engineering challenges for critical infrastructure, which included several instructors from inside and outside Idaho: 2013
- Initiated Special Issue on Resilient Control in the IEEE Transactions on Cybernetics: 2013
- Initiated/guided IEEE IES Technical Committee on Resilience and Security for Industrial Applications: 2011-Present
- Initiated/guided International Symposium on Resilient Control Systems, now evolved to Resilience Week: 2008-Present
- Established Grand Challenge in Resilient Controls and Definition: 2008-2009

Current and Pending Project and Proposal Submissions
Idaho National Lab – Craig Rieger

Support: ☒ Current ☐ Pending
Proposal Title: Anomaly Detection of Cyber Physicals Systems
Proposal Summary: Development of resilience metrics for mission assurance and the development/integration of power system transients into an anomaly detector for cyber attacks
Source of support: DoD-ONR
Total Award Amount: $680k Period of Performance: 3 years
Prime applicant and list of subawards: INL
Technical Contact: Craig Rieger Business/Administrative Contact: Craig Rieger
Person-Months Per Year Committed to the Project 0.15
Relation to and overlap with this proposal: Considers correlation of physical anomalies as a cyber detection method

Support: ☒ Current ☐ Pending
Proposal Title: More Situational Awareness for Industrial Control System
Proposal Summary: Integration of off-the-shelf and selective government developed tools, analytics and visualizations for effective operator response to cyber attack
Source of support: DoD/DOE
Total Award Amount: $700k Period of Performance: 2.4 years
Prime applicant and list of subawards: INL
Technical Contact: Craig Rieger Business/Administrative Contact: Craig Rieger
Person-Months Per Year Committed to the Project 0.2
Relation to and overlap with this proposal: None

Support: ☒ Current ☐ Pending
Proposal Title: Grid Modernization Laboratory Consortium
Proposal Summary: Development of resilience metrics for weighing operations for integrating energy resources into distribution systems
Source of support: DOE-OE/EERE
Total Award Amount: $800k Period of Performance: 2 years
Prime applicant and list of subawards: INL
Technical Contact: Craig Rieger Business/Administrative Contact: Craig Rieger
Person-Months Per Year Committed to the Project 0.15
Relation to and overlap with this proposal: None

Support: ☒ Current ☐ Pending
Proposal Title: Resilient, Scalable Cyber State Awareness of Industrial Control System Networks to Threat
Proposal Summary: Artificial intelligence methods to fuse live cyber and physical data to develop correlations for cyber attack
Source of support: INL
Total Award Amount: $875k Period of Performance: 3 years
Prime applicant and list of subawards: INL
Technical Contact: Craig Rieger Business/Administrative Contact: Craig Rieger
Person-Months Per Year Committed to the Project
Relation to and overlap with this proposal: Considers cyber and physical anomalies for characterizing cyber attack

Support: ☐ Current ☒ Pending
Proposal Title: (b) (4) [redacted]
Proposal Summary: (b) (4) [redacted]
Source of support: (b) (4) [redacted]
Total Award Amount: (b) [redacted] Period of Performance: 3 years
Prime applicant and list of subawards: INL

Technical Contact: Craig Rieger	Business/Administrative Contact: Craig Rieger
Person-Months Per Year Committed to the Project	0.15
Relation to and overlap with this proposal: (b)	

RESEARCH & RELATED BUDGET - Budget Period 1

OMB Number: 4040-0001
Expiration Date: 10/31/2019

ORGANIZATIONAL DUNS: 009095365 **Enter name of Organization:** University of Utah

Budget Type: ☒ Project ☐ Subaward/Consortium **Budget Period: 1** **Start Date:** 07/01/2018 **End Date:** 06/30/2019

A. Senior/Key Person

Prefix	First	Middle	Last	Suffix	Base Salary ($)	Months Cal.	Months Acad.	Months Sum.	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
	Masood		Parvania		(b) (4)	1.50			(b) (4)	(b) (4)	(b) (4)
Project Role:	PD/PI										
	SNEHA	K	KASERA		(b) (4)	0.30			(b) (4)	(b) (4)	(b) (4)
Project Role:	Faculty										
	ANGELA		RASMUSSEN		(b) (4)	0.50			(b) (4)	(b) (4)	(b) (4)
Project Role:	Faculty										
	Dean		Gallagher		(b) (4)	0.00			(b) (4)	(b) (4)	(b) (4)
Project Role:	Technology Commercialization										

Additional Senior Key Persons: Add Attachment | Delete Attachment | View Attachment

Total Funds requested for all Senior Key Persons in the attached file

Total Senior/Key Person (b) (4)

B. Other Personnel

Number of Personnel	Project Role	Months Cal.	Months Acad.	Months Sum.	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
2	Post Doctoral Associates	12.00			(b) (4)	(b) (4)	(b) (4)
3	Graduate Students	12.00			(b) (4)	(b) (4)	(b) (4)
	Undergraduate Students						
	Secretarial/Clerical						

5 **Total Number Other Personnel**

Total Other Personnel (b) (4)

Total Salary, Wages and Fringe Benefits (A+B) 254,534.00

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment item	Funds Requested ($)
Cyber-physical microgrid testbed equipment	180,945.00

Additional Equipment: Add Attachment | Delete Attachment | View Attachment

Total funds requested for all equipment listed in the attached file	
Total Equipment	180,945.00

D. Travel

	Funds Requested ($)
1. Domestic Travel Costs (Incl. Canada, Mexico and U.S. Possessions)	10,000.00
2. Foreign Travel Costs	0.00
Total Travel Cost	10,000.00

E. Participant/Trainee Support Costs

	Funds Requested ($)
1. Tuition/Fees/Health Insurance	
2. Stipends	
3. Travel	
4. Subsistence	
5. Other	
Number of Participants/Trainees / **Total Participant/Trainee Support Costs**	

F. Other Direct Costs

		Funds Requested ($)
1.	Materials and Supplies	
2.	Publication Costs	1,000.00
3.	Consultant Services	
4.	ADP/Computer Services	
5.	Subawards/Consortium/Contractual Costs	(b) (4)
6.	Equipment or Facility Rental/User Fees	
7.	Alterations and Renovations	
8.		
9.		
10.		
	Total Other Direct Costs	183,481.00

G. Direct Costs

	Funds Requested ($)
Total Direct Costs (A thru F)	628,960.00

H. Indirect Costs

Indirect Cost Type	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)
MTDC_Research	(b) (4)	(b) (4)	(b) (4)
		Total Indirect Costs	(b) (4)

Cognizant Federal Agency
(Agency Name, POC Name, and POC Phone Number)

DHHS, Arif Karim, 415-437-7820

I. Total Direct and Indirect Costs

	Funds Requested ($)
Total Direct and Indirect Institutional Costs (G + H)	781,491.00

J. Fee

Funds Requested ($)

K. Total Costs and Fee

	Funds Requested ($)
Total Costs and Fee (I + J)	781,491.00

L. Budget Justification

(Only attach one file.) UU_BUDGET_Justification_Final102403680 Add Attachment Delete Attachment View Attachment

RESEARCH & RELATED BUDGET - Budget Period 2

OMB Number: 4040-0001
Expiration Date: 10/31/2019

ORGANIZATIONAL DUNS: 009095365 **Enter name of Organization:** University of Utah

Budget Type: ☒ Project ☐ Subaward/Consortium **Budget Period: 2** **Start Date:** 07/01/2019 **End Date:** 06/30/2020

A. Senior/Key Person

Prefix	First	Middle	Last	Suffix	Base Salary ($)	Months Cal.	Months Acad.	Months Sum.	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
	Masood		Parvania		(b) (4)	1.50			(b) (4)	(b) (4)	(b) (4)
Project Role:	PD/PI										
	SNEHA	K	KASERA		(b) (4)	0.30			(b) (4)	(b) (4)	(b) (4)
Project Role:	Faculty										
	ANGELA		RASMUSSEN		(b) (4)	0.50			(b) (4)	(b) (4)	(b) (4)
Project Role:	Faculty										
	Dean		Gallagher		(b) (4)	0.00			(b) (4)	(b) (4)	(b) (4)
Project Role:	Technology Commercialization										

Additional Senior Key Persons: Add Attachment | Delete Attachment | View Attachment

Total Funds requested for all Senior Key Persons in the attached file

Total Senior/Key Person (b) (4)

B. Other Personnel

Number of Personnel	Project Role	Months Cal.	Months Acad.	Months Sum.	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
2	Post Doctoral Associates	12.00			(b) (4)	(b) (4)	(b) (4)
3	Graduate Students	12.00			(b) (4)	(b) (4)	(b) (4)
	Undergraduate Students						
	Secretarial/Clerical						

5 **Total Number Other Personnel**

Total Other Personnel (b) (4)

Total Salary, Wages and Fringe Benefits (A+B) 262,171.00

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment item	Funds Requested ($)

Additional Equipment: Add Attachment | Delete Attachment | View Attachment

Total funds requested for all equipment listed in the attached file	
Total Equipment	

D. Travel

	Funds Requested ($)
1. Domestic Travel Costs (Incl. Canada, Mexico and U.S. Possessions)	10,000.00
2. Foreign Travel Costs	
Total Travel Cost	10,000.00

E. Participant/Trainee Support Costs

	Funds Requested ($)
1. Tuition/Fees/Health Insurance	
2. Stipends	
3. Travel	
4. Subsistence	
5. Other	
Number of Participants/Trainees / **Total Participant/Trainee Support Costs**	

F. Other Direct Costs

		Funds Requested ($)
1.	Materials and Supplies	
2.	Publication Costs	1,000.00
3.	Consultant Services	
4.	ADP/Computer Services	
5.	Subawards/Consortium/Contractual Costs	(b) (4)
6.	Equipment or Facility Rental/User Fees	
7.	Alterations and Renovations	
8.	Organizing cost of conference and career expo	6,000.00
9.		
10.		
	Total Other Direct Costs	198,176.00

G. Direct Costs

	Funds Requested ($)
Total Direct Costs (A thru F)	470,347.00

H. Indirect Costs

Indirect Cost Type	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)
MTDC_Research	(b) (4)	(b) (4)	(b) (4)
		Total Indirect Costs	(b) (4)

Cognizant Federal Agency
(Agency Name, POC Name, and POC Phone Number)

DHHS, Arif Karim, 415-437-7820

I. Total Direct and Indirect Costs

	Funds Requested ($)
Total Direct and Indirect Institutional Costs (G + H)	616,912.00

J. Fee

Funds Requested ($)

K. Total Costs and Fee

	Funds Requested ($)
Total Costs and Fee (I + J)	616,912.00

L. Budget Justification

(Only attach one file.) UU_BUDGET_Justification_Final102403680 Add Attachment Delete Attachment View Attachment

RESEARCH & RELATED BUDGET - Budget Period 3

OMB Number: 4040-0001
Expiration Date: 10/31/2019

ORGANIZATIONAL DUNS: 009095365 **Enter name of Organization:** University of Utah

Budget Type: ☒ Project ☐ Subaward/Consortium **Budget Period: 3** **Start Date:** 07/01/2020 **End Date:** 06/30/2021

A. Senior/Key Person

Prefix	First	Middle	Last	Suffix	Base Salary ($)	Months Cal.	Months Acad.	Months Sum.	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
	Masood		Parvania		(b) (4)	1.50			(b) (4)	(b) (4)	(b) (4)
Project Role:	PD/PI										
	SNEHA	K	KASERA		(b) (4)	0.30			(b) (4)	(b) (4)	(b) (4)
Project Role:	Faculty										
	ANGELA		RASMUSSEN		(b) (4)	0.50			(b) (4)	(b) (4)	(b) (4)
Project Role:	Faculty										
	Dean		Gallagher		(b) (4)	0.00			(b) (4)	(b) (4)	(b) (4)
Project Role:	Technology Commercialization										

Additional Senior Key Persons: Add Attachment | Delete Attachment | View Attachment

Total Funds requested for all Senior Key Persons in the attached file

Total Senior/Key Person (b) (4)

B. Other Personnel

Number of Personnel	Project Role	Months Cal.	Months Acad.	Months Sum.	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
2	Post Doctoral Associates	12.00			(b) (4)	(b) (4)	(b) (4)
3	Graduate Students	12.00			(b) (4)	(b) (4)	(b) (4)
	Undergraduate Students						
	Secretarial/Clerical						

5 **Total Number Other Personnel**

Total Other Personnel (b) (4)

Total Salary, Wages and Fringe Benefits (A+B) 270,036.00

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment item	Funds Requested ($)

Additional Equipment: Add Attachment | Delete Attachment | View Attachment

Total funds requested for all equipment listed in the attached file	
Total Equipment	

D. Travel

	Funds Requested ($)
1. Domestic Travel Costs (Incl. Canada, Mexico and U.S. Possessions)	10,000.00
2. Foreign Travel Costs	
Total Travel Cost	10,000.00

E. Participant/Trainee Support Costs

	Funds Requested ($)
1. Tuition/Fees/Health Insurance	
2. Stipends	
3. Travel	
4. Subsistence	
5. Other	
Number of Participants/Trainees / **Total Participant/Trainee Support Costs**	

F. Other Direct Costs

		Funds Requested ($)
1.	Materials and Supplies	
2.	Publication Costs	1,000.00
3.	Consultant Services	
4.	ADP/Computer Services	
5.	Subawards/Consortium/Contractual Costs	(b) (4)
6.	Equipment or Facility Rental/User Fees	
7.	Alterations and Renovations	
8.	Organizing cost of conference and career expo	6,000.00
9.		
10.		
	Total Other Direct Costs	169,052.00

G. Direct Costs

	Funds Requested ($)
Total Direct Costs (A thru F)	449,088.00

H. Indirect Costs

Indirect Cost Type	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)
MTDC_Research	(b) (4)	(b) (4)	(b) (4)
		Total Indirect Costs	(b) (4)

Cognizant Federal Agency
(Agency Name, POC Name, and POC Phone Number)

DHHS, Arif Karim, 415-437-7820

I. Total Direct and Indirect Costs

	Funds Requested ($)
Total Direct and Indirect Institutional Costs (G + H)	599,782.00

J. Fee

Funds Requested ($)

K. Total Costs and Fee

	Funds Requested ($)
Total Costs and Fee (I + J)	599,782.00

L. Budget Justification

(Only attach one file.) UU_BUDGET_Justification_Final102403680 Add Attachment Delete Attachment View Attachment

RESEARCH & RELATED BUDGET - Cumulative Budget

		Totals ($)
Section A, Senior/Key Person		(b) (4)
Section B, Other Personnel		(b) (4)
Total Number Other Personnel	15	
Total Salary, Wages and Fringe Benefits (A+B)		(b) (4)
Section C, Equipment		180,945.00
Section D, Travel		30,000.00
1. Domestic	30,000.00	
2. Foreign	0.00	
Section E, Participant/Trainee Support Costs		
1. Tuition/Fees/Health Insurance		
2. Stipends		
3. Travel		
4. Subsistence		
5. Other		
6. Number of Participants/Trainees		
Section F, Other Direct Costs		550,709.00
1. Materials and Supplies		
2. Publication Costs	3,000.00	
3. Consultant Services		
4. ADP/Computer Services		
5. Subawards/Consortium/Contractual Costs	(b) (4)	
6. Equipment or Facility Rental/User Fees		
7. Alterations and Renovations		
8. Other 1	12,000.00	
9. Other 2		
10. Other 3		
Section G, Direct Costs (A thru F)		1,548,395.00
Section H, Indirect Costs		449,790.00
Section I, Total Direct and Indirect Costs (G + H)		1,998,185.00
Section J, Fee		
Section K, Total Costs and Fee (I + J)		1,998,185.00

OMB Number: 4040-0001
Expiration Date: 10/31/2019

RESEARCH & RELATED Senior/Key Person Profile (Expanded)

PROFILE - Project Director/Principal Investigator

Prefix: Dr. * First Name: Masood Middle Name:
* Last Name: Parvania Suffix:
Position/Title: Assistant Professor Department: Electrical and Computer Eng
Organization Name: University of Utah Division:
* Street1: 50 S Central Campus Drive, Room 2110
Street2:
* City: Salt Lake City County/ Parish: Salt Lake
* State: UT: Utah Province:
* Country: USA: UNITED STATES * Zip / Postal Code: 84112-8930
* Phone Number: 8015850030 Fax Number:
* E-Mail: masood.parvania@utah.edu

Credential, e.g., agency login:

*** Project Role:** PD/PI **Other Project Role Category:**

Degree Type: Ph.D.
Degree Year: 2013

***Attach Biographical Sketch** Parvania_Biosketch1024036700 Add Attachment Delete Attachment View Attachment
Attach Current & Pending Support Current_and_Pending___Parvani Add Attachment Delete Attachment View Attachment

PROFILE - Senior/Key Person 1

Prefix: * First Name: SNEHA Middle Name: K
* Last Name: KASERA Suffix:
Position/Title: Associate Professor Department: SCHOOL OF COMPUTING
Organization Name: University of Utah Division: COLLEGE OF ENGINEERING
* Street1: 50 CENTRAL CAMPUS DR RM 3190
Street2:
* City: SALT LAKE CITY County/ Parish: SALT LAKE
* State: UT: Utah Province:
* Country: USA: UNITED STATES * Zip / Postal Code: 84112-9205
* Phone Number: (801) 581-4541 Fax Number:
* E-Mail: kasera@cs.utah.edu

Credential, e.g., agency login:

*** Project Role:** Faculty **Other Project Role Category:**

Degree Type: PhD, Computer Science
Degree Year: 1999

Attach Biographical Sketch kaseraCV1024036666.pdf Add Attachment Delete Attachment View Attachment
Attach Current & Pending Support kaseraCurPen1024036690.pdf Add Attachment Delete Attachment View Attachment

RESEARCH & RELATED Senior/Key Person Profile (Expanded)

PROFILE - Senior/Key Person 2

Prefix: | * First Name: ANGELA | Middle Name:

* Last Name: RASMUSSEN | Suffix:

Position/Title: Assistant Professor (Lecturer) | Department: ELECT & COMPUTER ENGINEERING

Organization Name: University of Utah | Division: COLLEGE OF ENGINEERING

* Street1: 50 CENTRAL CAMPUS DR RM 3280

Street2:

* City: SALT LAKE CITY | County/ Parish: SALT LAKE

* State: UT: Utah | Province:

* Country: USA: UNITED STATES | * Zip / Postal Code: 84112-8930

* Phone Number: 801/581-6952 | Fax Number:

* E-Mail: AngelaRasmussen@comcast.net

Credential, e.g., agency login:

*** Project Role:** Faculty | **Other Project Role Category:**

Degree Type:

Degree Year:

Attach Biographical Sketch Angela_CV1024036762.pdf | Add Attachment | Delete Attachment | View Attachment

Attach Current & Pending Support Current_and_Pending___Angela1 | Add Attachment | Delete Attachment | View Attachment

PROFILE - Senior/Key Person 3

Prefix: | * First Name: Dean | Middle Name:

* Last Name: Gallagher | Suffix:

Position/Title: Technology Licensing Manager | Department: Technology and Venture Commerc

Organization Name: University of Utah | Division:

* Street1: 615 Arapeen Dr Suite 310

Street2:

* City: Salt Lake City | County/ Parish: Salt Lake

* State: UT: Utah | Province:

* Country: USA: UNITED STATES | * Zip / Postal Code: 84112-8930

* Phone Number: 8015850396 | Fax Number:

* E-Mail: dean.gallagher@tvc.utah.edu

Credential, e.g., agency login:

*** Project Role:** Other (Specify) | **Other Project Role Category:** Senior Personnel

Degree Type:

Degree Year:

Attach Biographical Sketch DeanGallagherCV1024036763.pdf | Add Attachment | Delete Attachment | View Attachment

Attach Current & Pending Support Current_and_Pending___Dean_Ga | Add Attachment | Delete Attachment | View Attachment

RESEARCH & RELATED Other Project Information

OMB Number: 4040-0001
Expiration Date: 10/31/2019

1. Are Human Subjects Involved? ☐ Yes ☒ No

1.a. If YES to Human Subjects

Is the Project Exempt from Federal regulations? ☐ Yes ☐ No

If yes, check appropriate exemption number. ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8

If no, is the IRB review Pending? ☐ Yes ☐ No

IRB Approval Date:

Human Subject Assurance Number:

2. Are Vertebrate Animals Used? ☐ Yes ☒ No

2.a. If YES to Vertebrate Animals

Is the IACUC review Pending? ☐ Yes ☐ No

IACUC Approval Date:

Animal Welfare Assurance Number:

3. Is proprietary/privileged information included in the application? ☐ Yes ☒ No

4.a. Does this Project Have an Actual or Potential Impact - positive or negative - on the environment? ☐ Yes ☒ No

4.b. If yes, please explain:

4.c. If this project has an actual or potential impact on the environment, has an exemption been authorized or an environmental assessment (EA) or environmental impact statement (EIS) been performed? ☐ Yes ☐ No

4.d. If yes, please explain:

5. Is the research performance site designated, or eligible to be designated, as a historic place? ☐ Yes ☒ No

5.a. If yes, please explain:

6. Does this project involve activities outside of the United States or partnerships with international collaborators? ☐ Yes ☒ No

6.a. If yes, identify countries:

6.b. Optional Explanation:

7. Project Summary/Abstract Project_Abstract1024036814.pdf [Add Attachment] [Delete Attachment] [View Attachment]

8. Project Narrative Proposal_ONR_DURA_UU1024036786.pdf [Add Attachment] [Delete Attachment] [View Attachment]

9. Bibliography & References Cited References1024036787.pdf [Add Attachment] [Delete Attachment] [View Attachment]

10. Facilities & Other Resources [Add Attachment] [Delete Attachment] [View Attachment]

11. Equipment [Add Attachment] [Delete Attachment] [View Attachment]

12. Other Attachments [Add Attachments] [Delete Attachments] [View Attachments] ☐

Project Abstract

Microgrids provide a solution for enhancing the reliability and resilience of the power grids, ensuring that critical operations can be sustained during prolonged utility power outages. Microgrid operators, however, do not have the luxury of large staffs, and are dependent upon advanced diagnostics and automation to successfully operate with fewer staff. While moving toward a more autonomous operation addresses this need, the Achilles Heel of these designs is in the identification and mitigation of any cyber-physical degrading effects. In addition, microgrid controllers need to act incredibly fast in order to seamlessly restore power to the facility after the power outage, specifically when involving high-dynamic loads and renewable energy sources (RES). The current microgrid controllers, however, integrate discrete-time controllers that do not appropriately account for the fast dynamics and variations of load and RES.

This project proposes to develop novel technologies for *continuous-time cyber physical control, health assessment and resilient response for microgrids*. The proposed technologies would significantly enhance the cyber-physical resilience of microgrids, by developing the next generation of continuous-time microgrid controllers with built-in cyber-physical resilience solutions. The technologies will be developed in four research Thrusts: 1) Continuous-time multi-time-scale microgrid controller that would co-optimize the microgrid operation in both faster time-scale of dynamic frequency control and the slower time scale of scheduling decisions; 2) Automated health assessment system that will fuse both physical and cyber information in order to detect any cyber attack in microgrid networks using novel automaton-based and conservation-based algorithms; 3) Automated response and recovery control system that seamlessly responds to the detected attacks/failures and brings back the microgrid to its normal operation; 4) Developing a cyber-physical microgrid testbed to implement, test and validate the technologies.

In addition to technology development, this project will execute a comprehensive plan for technology maturation, technology adoption by defense/commercial sector, and workforce/ professional development, which is carefully designed to advance the ONR's DURA initiative.

The technology maturation process will include organizing Lean Canvas Cohort for market analysis and business strategy development by the Technology and Venture Commercialization office at the University of Utah. The Utah Science, Technology and Research Initiative (USTAR) will also support and guide the technology commercialization activities by the project team, through providing business incubators and multiple grant programs aimed at technology maturation and commercialization.

This project involves three major partners, Utah Governor's Office of Energy Development, Utah Department of Veterans and Military Affairs, and Western Electricity Coordinating Council, who will work with the project team in order to promote the adoption of the technologies in the defense and commercial sectors. The project team will launch and host two Western Power Grid Resilience Conference in the second and third years of the project to highlight the latest development on microgrid and grid resilience research, as well as technology deployment.

This project will execute multiple activities for workforce and professional development, which include hands-on microgrid training, Entrepreneurship training, Professional Development and Career Preparation, and organizing a Power and Energy Career Expo. This project will also specifically target to engage the reserve Navy officers of the University of Utah NROTC in the activities. We anticipate that the technologies and partnerships developed through this project would lead in many new microgrid and energy resilience projects, creating new jobs in the local and regional energy industry.

Budget Justification
University of Utah

A. Senior Personnel

Dr. Masood Parvania: Dr. Parvania is an Assistant Professor in the Electrical and Computer Engineering Department (ECE) and the Director of the Utah Smart Energy Lab at the University of Utah. He will be the PI for this project. This budget includes 1.5 months support for his time each at year of this 3-year project. Base salary is $ [redacted] PI Parvania will be responsible for project management, and conducting and co-advising the PhD students and postdoctoral researchers to advance the research thrusts. He will lead the project team for executing the technology maturation and workforce/professional development activities. He will also develop curriculum for a hands-on microgrid training lab at the ECE department.

Dr. Sneha Kumar Kasera: Dr. Kasera is a Professor in the School of Computing, and the Director of Advanced Networked Systems Research (ANSR) lab at the University of Utah. Dr. Kasera is a expert on computer networks encompassing technologies, protocols and applications related to security, privacy, and reliability, as well as cyber-physical network security and privacy. He will serve as Senior Personnel in this project, and will work with PI Parvania to co-advise one PhD student to advance the research Thrusts 2 and 4. This budget includes 0.3 months support for his time at each year of this 3-year project. Base salary is $[redacted].

Dr. Angela Rasmussen: Dr. Rasmussen is an Associate Professor and the Director of Mentoring and Advising Office at the department of Electrical and Computer Engineering at the University of Utah. Dr. Rasmussen will serve as the Senior Workforce and Professional Development Personnel in this project and work with PI Parvania to advance the proposed workforce/professional development plan that includes: coordinating with the Lassonde Entrepreneurship Institute for executing the proposed Entrepreneurship training plan, coordinating with the Career and Professional Development Center for organizing the Power and Energy Career Expo and the Professional Development and Career Preparation trainings, as well as advising the reserve Navy officers at the University of Utah NROTC to engage in the program and take the hands-on training and special project courses in summer. This budget includes 0.5 months support for her time at the second and third years of this project. Base salary is $[redacted].

Mr. Dean Gallagher: Mr. Dean Gallagher is the Technology Licensing Manager at the Technology and Venture Commercialization office (TVC) at the University of Utah. Mr. Gallagher has over 30 years of experience in project management, engineering, construction, and operation of complex projects involving power systems, telecommunication networks, and engineering software development. Mr. Gallagher will serve as the Senior Technology Commercialization Personnel in this project and will work closely with PI Parvania to execute the proposed technology maturation plan, as well as activities to promote the technology adoption by the defense and commercial sector. Mr. Gallagher is a full-time employee of TVC and will collaborate with the project team as part of his regular job (see TVC letter of support).

B. Other Personnel

Postdoctoral Scholars:
The budget includes support for two Postdoctoral Scholars at the University of Utah. The Postdoctoral Scholars will work full-time (1.0 FTE) on the project during the 3-year performance

period of the project. Their duties will include working with PI Parvania and the Senior Personnel to conduct and advance the research thrusts, publishing papers, help mentoring the PhD students in the team, and participating in the technology maturation and workforce development plans. Base salary for each Postdoctoral Scholar is $(b) (4).

Graduate Student:
The budget includes support for 3 PhD students at the University of Utah. The students will be supported at half time (0.50 FTE) for the academic months and full time (1.0 FTE) during the summer months, and will work with PI Parvania and Senior Personnel to advance the research thrusts. Average base salary for each student is $(b) (4).

C. Fringe Benefits

Fringe benefits are calculated at the following rates for the project personnel:
PI and Senior Personnel: (b) (4) %
Postdoctoral Scholar: (b) (4) %
Graduate Student: (b) %

D. Travel

The budget includes travel fund of $30,000 to support the University of Utah team members' participation in domestic conferences to present the outcomes of the research during the 3-years period of this project. The travel fund would support four travel per for the project team at the University of Utah, for average cost of $2,500 for each travel that would include flight, hotel, registration and per diem. The target conferences include IEEE Power and Energy Society General Meeting, IEEE Innovative Smart Grid Technologies, IEEE Conference on Decision and Control (CDC), and INFORMS annual meeting, among others.

E. Equipment

The budget includes $180,944.8 funds for acquiring (b) (4)

F. Subcontract

This budget includes total funds of $(b) (4) for Idaho National Lab (INL) as the subcontract of this project. The INL team will work with PI Parvania and the project team at the University of Utah to advance the research Thrust 3, and participate in research Thrusts 2 and 4. Please see the management approach (Section 8 of the Project Narrative) for more details. Please see attached the detailed INL budget and budget justification.

G. Other Costs

Publication Costs

The budget includes $3,000 funds for publication costs to publish the results of our research over this 3-year project. The fund will cover journal over-page costs and production of posters for research meetings and conferences.

Conference and Career Expo Cost

The budget includes $12,000 funds to support organizing (b) (4) and two Power and Energy Career Expo. The conference and the expo will be held at the University Guest House, by the University of Utah Conference and Event Management Services (http://conferences.utah.edu/). We will organize 2 Conferences and 2 career expos during the second and third years of the project. The estimated cost of organizing each conference and expo is respectively calculated as $5000 and $1000 in consultation with the Conference and Event Management Services. The estimated conference costs for an estimated 100 attendees includes the costs of meeting hall and room, professional setup with tables and chairs as well as teardown after the event, food and beverages, audio and visual equipment, event management and website. The estimated career expo cost for estimated attendance of 20 companies includes the cost of expo hall, and professional setup with tables and chairs as well as teardown after the event.

The University of Utah Career and Professional Development Center (CPDC) will dedicate staff and personnel to hold the proposed career expo at no additional cost (see letter of support).

H. Indirect Costs

The University of Utah's indirect costs rate (Facilities and Administrative Costs) is based on Modified Total Direct Costs (MTDC), which is total direct costs less equipment above $5,000 and subcontract expenses in excess of $25,000 for each subcontract. The negotiated rate is (b) (4) % from 07/01/18 until amended. F&A agreement letter can be found at http://osp.utah.edu/resources/quick-reference/fa-rates.php

I. Cost-of-Living

The budget includes a 3% inflation rate added to years 2 and 3 of the detailed budget for the following areas: Personnel Salaries.

University of Utah
Real-Time Simulation
Microgrid Test Bench

Quote
TPIKQ1010-01
2018-02-10

University of Utah
Masood Parvania

Prepared By:
Thomas Kirk
Sales Engineer
514-898-9704

OPAL-RT TECHNOLOGIES

1751 Richardson St.
Suite 2525
Montreal QC H3K1G6
Canada
www.opal-rt.com

Tel: 514-898-9704
Fax:

QUOTE # TPIKQ1010-01

Date: 2018-02-10
Valid until: 2018-04-11

Customer Contact

Masood Parvania
University of Utah
50 S. Central Campus Drive Room 3280
Salt Lake City, Utah 84112-9206
United States
(801) 585-0030
masood.parvania@utah.edu

Opal-RT Contact

Thomas Kirk
Sales Engineer

514-898-9704

www.opal-rt.com

Line	Qty	Part #	Description	Unit List	Disc.	Total
1			**Microgrid HIL Test Bench**			
2			**HARDWARE**			
3	[redacted]	(b) (4)	[redacted]	[redacted]	(b) (4)	[redacted]
4	[redacted]	(b) (4)	[redacted] Linux	[redacted]	(b) (4)	[redacted]
5	[redacted]	(b) (4)	[redacted]	[redacted]	[redacted]	[redacted]
6	[redacted]	(b) (4)	[redacted]	[redacted]	[redacted]	[redacted]
7	[redacted]	(b) (4)	[redacted]	[redacted]	[redacted]	[redacted]
8	[redacted]	(b) (4)	[redacted]	[redacted]	[redacted]	[redacted]
9	[redacted]	(b) (4)	[redacted]	[redacted]	(b) (4)	[redacted]
10	[redacted]	(b) (4) FO	Time synchronization kit - Oregano for OP5707 (Input: SFP Sync: FO)	[redacted]	(b) (4)	[redacted]
11	[redacted]	(b) (4)	[redacted]	[redacted]	(b) (4)	[redacted]
12			SubTotal			(b) (4) $
13						
14			**MAPPING BOXES**			
15	[redacted]	(b) (4)	[redacted]	[redacted]	[redacted]	[redacted]
16	[redacted]	(b `	[redacted]	[redacted]	[redacted]	[redacted]
17	[redacted]	(	[redacted]	[redacted]	[redacted]	[redacted]
18	[redacted]	(b `	[redacted]	[redacted]	[redacted]	[redacted]
19			SubTotal			(b) (4) $
20						
21			**SOFTWARE Licenses (Real-Time and Host) and Support/Maintenance (5 Years Total)**			
22	[redacted]	(b) (4)	[redacted]	[redacted]	[redacted]	[redacted]

OPAL-RT TECHNOLOGIES

1751 Richardson St.
Suite 2525
Montreal QC H3K1G6
Canada
www.opal-rt.com

Tel: 514-898-9704
Fax:

QUOTE # TPIKQ1010-01

Date: 2018-02-10
Valid until: 2018-04-11

Customer Contact

Masood Parvania
University of Utah
50 S. Central Campus Drive Room 3280
Salt Lake City, Utah 84112-9206
United States
(801) 585-0030
masood.parvania@utah.edu

Opal-RT Contact

Thomas Kirk
Sales Engineer

514-898-9704

www.opal-rt.com

Line	Qty	Part #	Description	Unit List	Disc.	Total
23	[redacted]	(b) (4)	[redacted]	[redacted]	[redacted]	[redacted]
24	[redacted]	(b) (4)	[redacted]	[redacted]	[redacted]	[redacted]
25	[redacted]	(b) (4)	[redacted]	[redacted]	[redacted]	[redacted]
26			SubTotal			(b) (4) $
27						
28			**COMMUNICATION PROTOCOLS**			
29	[redacted]	(b) (4)	[redacted]	[redacted]	[redacted]	[redacted]
30	[redacted]	(b) (4)	[redacted]	[redacted]	[redacted]	[redacted]
31	[redacted]	(b) (4)	[redacted]	[redacted]	[redacted]	[redacted]
32	[redacted]	(b) (4)	[redacted]	[redacted]	[redacted]	[redacted]
33			SubTotal			(b) (4) $

Sub-Total	$179,944.89
Shipping & Handling	$1,000.00
Total	180,944.89 $

TERMS AND CONDITIONS OF SALES

As stated herein, 'Seller' is OPAL-RT Technologies Inc. and the 'Buyer' is the recipient of the quotation and issuer of the purchase order. The following terms and conditions of sales apply to the Seller's quotations and any sales that result.

1. GENERAL

1.1. Quotations are offered for acceptance within thirty (30) days unless a longer time is specified on the face of the quotation, and if not so accepted within the designated period shall be deemed withdrawn.

1.2. All purchase orders are subject to these Terms and Conditions.

1.3. The Seller reserves the right to vary these Terms and Conditions on 30 days' notice to the Buyer.

1.4. In these Terms and Conditions, the expression "Goods" relates to the goods and services, which the Seller proposes to sell or has sold to the Buyer, being the Goods described in the Seller's Quotation and a reference to Goods includes services and electronic products of any kind.

2. ACCEPTANCE OF QUOTATION AND PURCHASE ORDERS

2.1. The quotation must be accepted by the Buyer in writing by counter-signature of the quotation for any quotation above $100,000 US and by electronic confirmation to the Seller for the others.

2.2. Seller's acceptance of any purchase order is contingent upon Seller's approval of Buyer's credit.

2.3. Acceptance of the Buyer's purchase orders by the Seller does not constitute acceptance of the Buyers' terms and conditions of sale quoted therein, unless specifically authorized with the written consent by the Seller. In the event of the lack of enforcement of the Seller's terms and conditions of sale by the Seller or by the agent of the Seller or by the Seller's subsidiary, neither waiver of the Seller's terms and condition of sales, nor the Seller's acceptance of Buyer's conditions of purchase is to be deemed or implied. In any event, if the Buyer fails to notify the Seller in writing within ten (10) days of the Seller's order acknowledgement that any terms or conditions of that order are unacceptable to the Buyer, the Buyer shall be deemed to have accepted the Contract as set forth in the acknowledgement. Upon acceptance in this manner, the Contract cannot be canceled, revoked, or modified in any particular without the specific written consent of the Seller, after appropriate provision for payment by the Buyer for any additional costs and expenses resulting from such changes.

3. DELIVERY

3.1. All delivery dates quoted are estimated, are not guaranteed and do not form a term of this Contract. The Seller undertakes to make every endeavor to adhere to the delivery schedule but will not accept cancellation of Contract for, or liability for, any direct or indirect losses which may arise from late delivery .

3.2. Unless otherwise agreed in writing by the Seller, all costs of delivery will be for the Buyer's account.

3.3. The Seller is not and will not be liable for any loss or damage however it arises because of any failure to deliver or delay in delivery for any reason including, without limitation:

3.3.1. Acts of God, fire, lightning ,explosion, or flood; lock-out, strike or other labor difficulty;

3.3.2. shortage or unavailability of raw materials, labor, power supplies or transport facilities; or failure or inability to obtain licenses or the effect of any applicable laws, orders, rules or regulations of any government or competent authority

3.3.3. Breakage, accident or other damage to or failure of machinery or equipment.

4. DAMAGE OR LOSS IN TRANSIT

4.1. All Goods are delivered FOB Clent's facility and the Seller accepts no responsibility past the Client's facility for damage or loss of Goods in transit. Any such damage should be noted on the carriers paperwork and notified to the Seller within four days of receipt and the Goods held for inspection to enable a claim to be made on the carrier. If the Goods are lost or not received by the Buyer within six days of invoice, the Seller should be immediately notified.

4.2. In particular, at the time of delivery, the Buyer should verify the condition of the tape used for packaging of goods shipped, and notify the Seller of any issue at support@opal-rt.com. Failure to report any damage to the sealing tape of the shipped Goods will result in the Buyer being held responsible for all cost of damages.

5. PRICE AND QUOTATION

5.1. Unless otherwise agreed to in writing by the Seller, all quotations expire 30 days from the date of the quotation. Prices are thereafter subject to change without notice and Goods will be invoiced at the price ruling at the date of dispatch.

5.2. All Goods will be charged at the prices ruling at the date of order plus any applicable Goods and Services Tax (GST) which must be paid to the Seller by the Buyer when payment for the Goods is due.

5.3. Prices will be rounded to the nearest whole cent in the Seller's invoices.

5.4. When preparing a quote, the Seller uses its best knowledge to estimate the necessary time for training, commissioning or giving expert services. If it happens that more time is necessary to complete the work, then the Seller will charge the Buyer all overtime hours at 1,25 X the regular rate.

6. TERMS OF PAYMENT

6.1. For orders including software only, payment must be made in cash without deduction within 30 days of the date of invoice or by letter of credit approved by the Seller, unless otherwise provided in the Seller's Quotation or agreed in writing by the Seller or specified by the Seller at the time an order is received.

6.2. For orders including Seller's hardware or third party software or hardware, Seller will invoice Buyer immediately after reception of the purchase order and payment is due no later than 30 days after purchase order date through bank wire transfer. The Buyer understands that the Seller will not be able to deliver any systems unless the hardware and third party software have been fully paid.

6.3. For Seller's distributors, payment must be made according to distributorship agreement.

6.4. The Seller reserves the right to vary the terms of payment and to require payment in cash in full prior to delivery if, at any time, the credit worthiness of the Buyer is, in the

Seller's opinion, unsatisfactory. If the Buyer has not paid the Seller in full within 30 days of the payment being due, the Seller may, at its option, rescind the Contract and resell or dispose of the Goods without prejudice to any claims for damages against the Buyer.

6.5. Payment of invoices must be received not later than 30 days from the date of invoice, thereafter the Seller reserves the right to charge interest at the rate of 1% per month or part thereof for outstanding amounts owing by the Buyer.

6.6. Where payment is not received by the Seller within 30 days from the date of invoice, the Seller may in its absolute discretion:

a) Withhold further supply, activate software time locks and dispose of stock held for the order.

b) Institute legal action for recovery of outstanding balance plus interest and costs incurred, including legal costs; and

c) Require the Buyer to pay cash on delivery for any further Goods, and

d) The Seller shall not be liable to the Buyer for any loss or damage resulting directly or indirectly from such action.

7. CHANGES AND CANCELLATION

7.1. If the Buyer makes a change to an order causing a delivery delay or cancels an order less than thirty (30) days prior to scheduled shipment, Buyer shall pay to the Seller a fee equal to 5% of the list price of any Goods affected.

7.2. In addition, where any such change causes a delay in delivery of any Goods affected of greater than one (1) month from the proposed date of delivery for the Buyer's original order, the Buyer will be charged an extra 1% per month of the purchase order until final delivery.

7.3. If the Buyer cancels an order for any Goods not included in the Seller's current price list, any time after the order is received by the Seller then the Buyer will be subject to that additional charge.

7.4. If the Buyer cancels any order or refuses to accept all or any of the Goods in an order other than in circumstances permitted in these Conditions, the Buyer will be liable for any resulting damage or loss suffered by the Seller. If the Goods have been or are in the process of being manufactured or produced specifically for the Buyer, the Buyer will pay to the Seller as liquidated damages the full Contract price of the Goods and any costs incurred by the Seller (including, but without limitation, any GST) less the current scrap value of the Goods as determined by the Seller.

8. LIABILITY

8.1. LIMITED LIBALITILY : UNLESS OTHERWISE PROVIDED FOR IN THIS CONTACT, UNDER NO CIRCUMSTANCES WILL THE SELLER OR ITS SUB-CONTRACTORS OR SUPPLIERS BE LIABLE TOWARDS THE BUYER OR ANY THIRD PARTY FOR ANY, DIRECT, INDIRECT, SPECIAL, INCIDENTAL, PUNITIVE OR EXEMPLARY DAMAGES, OR CLAIMS OR COSTS OF ANY KIND INCLUDING, WITHOUT LIMITATION, ANY LOSS OF PROFITS OR OTHER ECONOMIC LOSS (RESULTING FROM A CONTRACTUAL OR EXTRA-CONTRACTUAL FAULT OR FROM NEGLIGENCE), ARISING OUT OF RELATED TO THE GOODS, EVEN IF THE SELLER HAS BEEN NOTIFIED OF THE POSSIBILITY OF SUCH DAMAGES. CERTAIN JURISDICTIONS PROHIBIT THE EXCLUSION OR LIMITATION OF LIABILITY FOR INDIRECT OR CONSEQUENTIAL DAMAGES, AND IT IS POSSIBLE THAT ONE OR MORE OF THE AFOREMENTIONED EXCLUSIONS OR LIMITATIONS WILL NOT APPLY TO THE BUYER. IT IS ALSO POSSIBLE THAT THE BUYER MAY HAVE OTHER RIGHTS, WHICH RIGHTS MAY VARY FROM ONE PLACE TO ANOTHER. UNDER NO CIRCUMSTANCES WILL THE SELLER TOTAL LIABILITY TOWARDS THE BUYER EXCEED THE VALUE OF THE GOODS TO THE BUYER OR THE VALUE OF THE PRODUCT IN DEFECT SUPPLIED BY THE SELLER AND PAID FOR BY THE BUYER

8.2. DISCLAIMER: Except in the event of willful misconduct or negligence on the part of Seller, the Seller shall not be liable towards the Buyer for any fault or any direct or indirect damage resulting from:

a) the Services conducted or performed by the Seller;

b) the work conducted or performed by the Buyer or its representative in collaboration with the Seller using or not the Seller's Goods, and:

c) the defect, the use or the results of the use of the Seller's Goods in terms of their correctness, accuracy, reliability or otherwise.

8.3. INDEMNIFICATION: The Buyer agrees to indemnify, hold harmless and defend the Seller from and against all damages, costs, losses, claims, causes of actions and lawsuits and expenses, including all claims under a warranty, reasonable attorneys' fees and costs, arising out of Buyer's use of the Goods in any of the following cases:

a) hardware or software modifications or additions made to the Buyer's computer equipment which affect the proper operation of the Seller's Goods;

b) the introduction of a computer virus into the Buyer's computer equipment which affects the proper operation of the Seller's Goods;

c) the migration of the Seller's Goods to a different hardware or software environment;

d) the loss of business opportunities or income relating to the operation or failure to operate the Seller's Goods; and

e) Unlawful or unauthorized third-party hacking into the Buyer's computer equipment.

9. FORCE MAJEURE EVENTS

9.1. Neither Party shall be liable for any delay in the performance of its obligations hereunder due to an adverse event caused by a superior force as awarded by a competent authority or court of law (hereinafter referred to as "Force Majeure"). For clarity, an event affecting Supplier's capabilities shall not be deemed a Force Majeure event merely due to Supplier's self-declaration or self-assessment thereof.

9.2. Supplier undertakes to (i) notify Buyer immediately of any event of Force Majeure and (ii) resume its performance forthwith after the Force Majeure event ceases. If any Force Majeure event continues for an unbroken period exceeding thirty (30) days, Buyer is entitled by notice in writing to the Supplier to terminate this Agreement and any order associated with it. In the event of such notice being given, all Services completed and accepted hereunder before the giving of such notice, and all Services completed and accepted thereafter in accordance with and to the extent specified in such notice, shall be paid for by Buyer subject to acceptance by Buyer. In no case under such termination shall Supplier be entitled to any amount which taken together with any amounts paid or due to Supplier under the terminated order, would exceed the total amount payable for the Services to be supplied under the terminated

10. PATENTS

10.1. The sale and purchase of the Goods does not confer on the Buyer any license or rights under any patents, trademarks or copyright which is the property of the Seller.

11. RETURN POLICY

11.1. The Seller warrants to the original Buyer and/or ultimate Buyer of the Seller's Goods that if any part thereof proves to be defective in material or workmanship within one (1) year after the delivery of the invoice, such defective part will be repaired or replaced, free of charge, at the Seller's discretion, if shipped prepaid to Opal-RT Technologies Inc. at 1751 Richardson, suite 2525, Montreal, Quebec, Canada, H3K 3G6, in a package equal to or in the original container. The Goods will be returned freight prepaid and repaired or replaced if it is determined by the Seller that the part failed due to defective materials or workmanship. Otherwise, the fees will be charged to the Buyer (see Warranty Policy and Liability on Opal-RT's web site at www.opal-rt.com , under Support, Return Merchandise, click on "Please read about our RMA procedure and warranty policy"). The repair or replacement of any such defective part shall be the Seller's sole and exclusive responsibility and liability under this limited warranty.

12. PREVAILING CONTRACT

12.1. These terms and conditions supersede any and all previous instruments unless otherwise provided by law, and no change or modification of these terms and conditions shall be of any force unless such change or modification shall be executed by an authorized officer of Seller. The terms and conditions of this instrument shall supersede any terms and conditions on any confirmation purchase orders or other documents Buyer may present, the terms and conditions herein being binding. Acceptance of any quotation is limited to the terms and conditions herein.

13. GOVERNING LAWS

13.1. This Contract created by Seller's quotation, Buyer's purchase order and Seller's acknowledgement shall be governed by, and construed in accordance with the laws of the province of Quebec and the laws of Canada applicable herein.

Masood Parvania, Ph.D.
Director, Utah Smart Energy Lab
Assistant Professor, Electrical and Computer Engineering
University of Utah
Salt Lake City, UT 84112
Office Phone: (801) 585-0030
masood.parvania@utah.edu

PROFESSIONAL PREPARATION

College/University	Major	Degree &Year
Arizona State University	Electrical Engineering	Postdoc., Jan.-June 2015
University of California Davis	Electrical Engineering	Postdoc., 2014
Sharif University of Technology	Electrical Engineering	Ph.D., 2013

APPOINTMENTS

2015-Present	Assistant Professor, Electrical & Computer Engineering	University of Utah
2012–2013	Research Associate, Electrical & Computer Engineering	Illinois Institute of Tech.

Select Publication

[1] M. Parvania, G. Koutsandria, V. Muthukumar, S. Peisert, C. McParland, and A. Scaglione, "Hybrid control network intrusion detection systems for automated power distribution systems," in *Proc. 44th Annual IEEE/IFIP International Conference on Dependable Systems and Networks (DSN)*, pp. 774-779, June 23, 2014.

[2] G. Koutsandria, V. Muthukumar, M. Parvania, S. Peisert, C. McParland, and A. Scaglione, "A Hybrid Network IDS for Protective Digital Relays in the Power Transmission Grid," in *Proc. 5th IEEE International Conference on Smart Grid Communications (SmartGridComm 2014)*, Nov. 3-6, 2014.

[3] *ASCR Cybersecurity for Scientific Computing Integrity*, U.S. Department of Energy, Workshop Report, January 7–9, 2015.

[4] R. Khatami, M. Parvania, P. Khargonekar, "Scheduling and Pricing of Energy Generation and Storage in Power Systems," *IEEE Transactions on Power Systems*, accepted, 2017.

[5] M. Parvania, R. Khatami, "Continuous-time Marginal Pricing of Electricity," *IEEE Transactions on Power Systems*, vol. 32, no. 3, pp. 1960-1969, May 2017.

[6] M. Parvania, A. Scaglione, "Unit Commitment with Continuous-time Generation and Ramping Trajectory Models," *IEEE Transactions on Power Systems*, vol. 31, no. 4, pp. 3169-3178, July 2016.

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[11] M. Parvania, M. Fotuhi-Firuzabad, "Demand Response Scheduling by Stochastic SCUC," *IEEE Transactions on Smart Grid*, vol. 1, no. 1, pp. 89–98, June 2010.

SYNERGISTIC ACTIVITIES

1. Journal Editorial Board Membership
   - 2015-2016, Guest Editor, *IEEE Transactions on Smart Grid*, Special Issue on Power Grid Resilience
   - 2016-Present, Associate Editor, *IEEE Transactions on Smart Grid*
   - 2017-Present, Associate Editor, *IEEE Power Engineering Letters*

2. Technical Committee Service at IEEE Power and Energy Society (PES)
   - 2012-present, Chair, IEEE PES Task Force on Reliability Impacts of Distributed Energy Resources
   - 2016-present, Vice-Chair, IEEE PES Bulk Power System Operation Subcommittee
   - 2014-present, Vice-Chair, IEEE PES Reliability, Risk and Probability Applications Subcommittee

3. Technical Program Committee Member of International Conferences
   - 2016, Technical Program Committee Member, *IEEE International Conference on Smart Grid Communications* (SmartGridComm 2016), Nov. 2016, Sydney, Australia
   - 2015, Technical Program Committee Member, *IEEE International Conference on Smart Grid Communications* (SmartGridComm 2015), Nov. 2015, Miami, FL

4. Service at Local IEEE Section
   - 2016-present, Chair, IEEE PES Utah Chapter
   - 2016-present, Faculty Adviser, IEEE PES University of Utah Student Chapter

5. Standard Development
   - 2012-present, Section Lead on Market Applications, *IEEE P1854™–Guide for Smart Distribution Applications*, IEEE Standards Association (the application guide is due to publish in 2017)

Current and Pending Project and Proposal Submissions
Masood Parvania

Support: ☒ Current ☐ Pending
Proposal Title: Stochastic Continuous-time Flexibility Scheduling and Pricing in Wholesale Electricity Markets
Proposal Summary: Developing stochastic continuous-time models for scheduling flexibility resources in markets
Source of support: DOE
Total Award Amount: $449,891 Period of Performance: 10/2017-09/2020
Prime applicant and list of subawards: University of Utah
Technical Contact: Masood Parvania Business/Administrative Contact: Jennifer Hoskins
Person-Months Per Year Committed to the Project 0.5
Relation to and overlap with this proposal: Stochastic continuous-time optimization for bulk power grid operation

Support: ☒ Current ☐ Pending
Proposal Title: WestSmartEV: Western Plugin Electric Vehicle Community Partnership
Proposal Summary: Studying the impacts of electric vehicle charging on power distribution systems
Source of support: DOE
Total Award Amount: $4,000,000 Period of Performance: 01/2017-01/2020
Prime applicant and list of subawards: PacifiCorp (Subawards: University of Utah, Utah State University, Idaho National Lab)
Technical Contact: Masood Parvania Business/Administrative Contact: Jennifer Hoskins
Person-Months Per Year Committed to the Project 1.0
Relation to and overlap with this proposal: None

Support: ☒ Current ☐ Pending
Proposal Title: A function space theory for continuous-time flexibility scheduling in electricity markets
Proposal Summary: Developing a function space theory for continuous-time operation of power grid
Source of support: NSF
Total Award Amount: $149,798 Period of Performance: 09/2015-08/2018
Prime applicant and list of subawards: University of Utah
Technical Contact: Masood Parvania Business/Administrative Contact: Jennifer Hoskins
Person-Months Per Year Committed to the Project Currently 0.0 (1.0 in the first two years of the project)
Relation to and overlap with this proposal: Continuous-time optimization but for bulk power grid operation

Support: ☒ Current ☐ Pending
Proposal Title: Automated Monitoring and Control of Electric Vehicle Charging Infrastructure
Proposal Summary: Developing control and monitoring systems for controlling the charge of Electric Vehicles
Source of support: USTAR / Utah Governor's Office of Energy Development
Total Award Amount: $125,000 Period of Performance: 02/2017-02/2018
Prime applicant and list of subawards: University of Utah
Technical Contact: Masood Parvania Business/Administrative Contact: Jennifer Hoskins
Person-Months Per Year Committed to the Project 0.5
Relation to and overlap with this proposal: None

Support: ☒ Current ☐ Pending
Proposal Title: Smart Water Data Acquisition and Analytics Technologies for Improving Efficiency of Water and Power Network Operations
Proposal Summary: Developing models for real-time co-optimization of power and water distribution systems
Source of support: USTAR / Utah Governor's Office of Energy Development
Total Award Amount: $125,000 Period of Performance: 08/2017-08/2018
Prime applicant and list of subawards: University of Utah
Technical Contact: Masood Parvania Business/Administrative Contact: Jennifer Hoskins
Person-Months Per Year Committed to the Project 0.5
Relation to and overlap with this proposal: None

Support: ☒ Current ☐ Pending
Proposal Title: Modeling Compressed Air Energy Storage in Power Systems
Proposal Summary: Developing models for operating compressed air energy storage devices
Source of support: Magnum Energy
Total Award Amount: $60,000 Period of Performance: 03/2017-03/2018
Prime applicant and list of subawards: University of Utah
Technical Contact: Masood Parvania Business/Administrative Contact: Jennifer Hoskins
Person-Months Per Year Committed to the Project 0.0
Relation to and overlap with this proposal: None

Support: ☐ Current ☒ Pending
Proposal Title: NRT: (b) (4)
Proposal Summary: (b) (4)
Source of support: (b)
Total Award Amount: (b) (4) Period of Performance: 08/2018-08/2023
Prime applicant and list of subawards: University of Utah
Technical Contact: Masood Parvania Business/Administrative Contact: Jennifer Hoskins
Person-Months Per Year Committed to the Project 0.25
Relation to and overlap with this proposal: (b)

Support: ☐ Current ☒ Pending
Proposal Title: (b) (4)
Proposal Summary: (b) (4)
Source of support: (b)
Total Award Amount: (b) (4) Period of Performance: 07/2018-07/2021
Prime applicant and list of subawards: University of Utah
Technical Contact: Masood Parvania Business/Administrative Contact: Jennifer Hoskins
Person-Months Per Year Committed to the Project 0.25
Relation to and overlap with this proposal: (b)

Project Abstract

Microgrids provide a solution for enhancing the reliability and resilience of the power grids, ensuring that critical operations can be sustained during prolonged utility power outages. Microgrid operators, however, do not have the luxury of large staffs, and are dependent upon advanced diagnostics and automation to successfully operate with fewer staff. While moving toward a more autonomous operation addresses this need, the Achilles Heel of these designs is in the identification and mitigation of any cyber-physical degrading effects. In addition, microgrid controllers need to act incredibly fast in order to seamlessly restore power to the facility after the power outage, specifically when involving high-dynamic loads and renewable energy sources (RES). The current microgrid controllers, however, integrate discrete-time controllers that do not appropriately account for the fast dynamics and variations of load and RES.

This project proposes to develop novel technologies for *continuous-time cyber physical control, health assessment and resilient response for microgrids*. The proposed technologies would significantly enhance the cyber-physical resilience of microgrids, by developing the next generation of continuous-time microgrid controllers with built-in cyber-physical resilience solutions. The technologies will be developed in four research Thrusts: 1) Continuous-time multi-time-scale microgrid controller that would co-optimize the microgrid operation in both faster time-scale of dynamic frequency control and the slower time scale of scheduling decisions; 2) Automated health assessment system that will fuse both physical and cyber information in order to detect any cyber attack in microgrid networks using novel automaton-based and conservation-based algorithms; 3) Automated response and recovery control system that seamlessly responds to the detected attacks/failures and brings back the microgrid to its normal operation; 4) Developing a cyber-physical microgrid testbed to implement, test and validate the technologies.

In addition to technology development, this project will execute a comprehensive plan for technology maturation, technology adoption by defense/commercial sector, and workforce/ professional development, which is carefully designed to advance the ONR's DURA initiative.

The technology maturation process will include organizing Lean Canvas Cohort for market analysis and business strategy development by the Technology and Venture Commercialization office at the University of Utah. The Utah Science, Technology and Research Initiative (USTAR) will also support and guide the technology commercialization activities by the project team, through providing business incubators and multiple grant programs aimed at technology maturation and commercialization.

This project involves three major partners, Utah Governor's Office of Energy Development, Utah Department of Veterans and Military Affairs, and Western Electricity Coordinating Council, who will work with the project team in order to promote the adoption of the technologies in the defense and commercial sectors. The project team will launch and host two Western Power Grid Resilience Conference in the second and third years of the project to highlight the latest development on microgrid and grid resilience research, as well as technology deployment.

This project will execute multiple activities for workforce and professional development, which include hands-on microgrid training, Entrepreneurship training, Professional Development and Career Preparation, and organizing a Power and Energy Career Expo. This project will also specifically target to engage the reserve Navy officers of the University of Utah NROTC in the activities. We anticipate that the technologies and partnerships developed through this project would lead in many new microgrid and energy resilience projects, creating new jobs in the local and regional energy industry.

References

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[2] M. Parvania, G. Koutsandria, V. Muthukumar, S. Peisert, C. McParland, and A. Scaglione, "Hybrid control network intrusion detection systems for automated power distribution systems," in *Proc. 44th Annual IEEE/IFIP International Conference on Dependable Systems and Networks (DSN)*, pp. 774-779, June 23, 2014.

[3] G. Koutsandria, V. Muthukumar, M. Parvania, S. Peisert, C. McParland, and A. Scaglione, "A Hybrid Network IDS for Protective Digital Relays in the Power Transmission Grid," in *Proc. 5th IEEE International Conference on Smart Grid Communications (SmartGridComm 2014)*, Nov. 3-6, 2014.

[4] Idaho National Lab, Resilient Control & Instrumentation Systems, https://icis.inl.gov

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[6] R. Khatami, M. Parvania, P. Khargonekar, "Scheduling and Pricing of Energy Generation and Storage in Power Systems," *IEEE Transactions on Power Systems*, accepted, 2017.

[7] M. Parvania, R. Khatami, "Continuous-time Marginal Pricing of Electricity," *IEEE Transactions on Power Systems*, vol. 32, no. 3, pp. 1960-1969, May 2017.

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[20] Utah Veteran Owned Business Partnership (UVOBP), https://veterans.utah.gov/business/

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[22] The University of Utah Veteran Support Center, https://veteranscenter.utah.edu/
[23] The University of Utah Lassonde Entrepreneur Institute, http://lassonde.utah.edu/

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[26] T. Vollmer and M. Manic, "Autonomic Intelligent Cyber Sensor to Support Industrial Control Network Awareness," *Transactions on Industrial Informatics*, Vol. 10, No. 2, May 2014.

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[28] Amit Pande, Vishal Ahuja, "WEAC: Word embeddings for anomaly classification from event logs", Big Data (Big Data) 2017 IEEE International Conference on, pp. 1095-1100, 2017.

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[30] Lean Canvas Cohort: http://www.tvc.utah.edu/lean-canvas/

[31] K. Oikonomou, V. Satyal, M. Parvania, "Energy Storage in the Western Interconnection: Current Adoption, Trends and Modeling Challenges," in *Proc. IEEE Power & Energy Society General Meeting*, Chicago, IL, July 16-20, 2017.

TECHNICAL PROPOSAL IN RESPONSE TO ONR FOA #N00014-18-S-F004
ONR DEFENSE UNIVERSITY RESEARCH-TO-ADOPTION (DURA) INITIATIVE

Project Title
Continuous-time Cyber-Physical Control, Health Assessment and Resilient Response for Microgrids

Project Team
University of Utah (Prime Applicant)
- Department of Electrical and Computer Engineering (Dr. Masood Parvania, PI)
- Department of Electrical and Computer Engineering (Dr. Angela Rasmussen)
- School of Computing (Dr. Sneha Kumar Kasera)
- Office of Technology and Venture Commercialization (Mr. Dean Gallagher)
- Lassonde Entrepreneur Institute (Dr. Troy D'Ambrosio)
- Veterans Support Center (Mr. Paul Morgan)
- Office of Corporate and Foundation Relations (Mr. Chris E. Ostrander)
- Career and Professional Development Center (Mr. Preston R. Nielson)
- Center for High Performance Computing

Idaho National Laboratory (Subcontract)
- Resilient Control & Instrumentation Systems (Dr. Craig Rieger)
- Technology Development Office

Project Partners
Utah Department of Veterans and Military Affairs (Mr. Ted Frederick)
- Utah Veteran Owned Business Partnership (Mr. Cory Pearson)

Utah Science, Technology and Research (USTAR) (Dr. Ivy Estabrooke, Exec. Director)
Utah Governor's Office of Energy Development (Dr. Laura Nelson, Exec. Director)
- Military Installation Energy Collaborative (Hill Air Force Base, Tooele Army Depot, Dugway Proving Ground, Utah Air National Guard) (Mrs. Shawna Cuan)

Western Electricity Coordinating Council (Dr. Vijay Satyal)

Principal Investigator and Technical Contact
Dr. Masood Parvania
Assistant Professor, Electrical and Computer Engineering
50 S. Central Campus Dr., Room 2110, Salt Lake City, UT 84112
Phone and Fax: (801) 585-0030, E-mail: masood.parvania@utah.edu

Administrative and Business Contact
Jennifer Hoskins
Contracts Administrator, Office of Sponsored Projects
75 S. 2000 E., Room 215, Salt Lake City, UT 84112
Phone and Fax: (801) 581-3005, E-mail: jennifer.hoskins@osp.utah.edu

Proposed Period of Performance
July 1st, 2018 – June 30th, 2021

Total Proposed Budget
The total project budget is $1,998,185.00

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1. Technical Approach: Continuous-time Cyber Physical Control, Health Assessment and Resilient Response for Microgrids

Microgrids provide a solution for enhancing the reliability and resilience of the power grids, ensuring that critical operations can be sustained during prolonged utility power outages. In addition, microgrids more efficiently manage electricity consumption at military installations, thus reducing petroleum demand, carbon emissions, and transportation costs. A recent joint effort between the DoD and DOE, named SPIDERS [1], aims to develop, install and validate scalable microgrid solutions to enhance the resiliency of operations in three DoD facilities at Hawaii and Colorado.

Microgrid operators, however, do not have the luxury of large staffs, and are dependent upon advanced diagnostics and automation to successfully operate with fewer staff. While moving toward a more autonomous system operation addresses this need, the Achilles Heel of these designs is in the identification and mitigation of any cyber-physical degrading effects. Cyber attacks and malicious manipulations in microgrids that initiate improper control actions, prevent critical control actions, and delay the delivery of critical sensor information are examples of such attacks and operation failures that are not necessarily revealed before the damaging effects [2]-[5]. Therefore, it is of paramount importance to develop technologies that ensure the microgrid operates properly during emergencies, and therefore, resilient by design. In addition, microgrid controllers need to act incredibly fast in order to seamlessly restore power to the facility after the power outage, specifically when involving high-dynamic loads and renewable energy sources (RES). The current microgrid controllers, however, integrate discrete-time controllers that do not appropriately account for the fast dynamics and variations of load and RES [6].

In this context, this project proposes to develop novel technologies for *continuous-time cyber physical control, health assessment and resilient response for microgrids*. The technologies, shown in Fig. 1, will be developed in four research Thrusts: 1) Continuous-time Multi-Time-Scale Microgrid Controller, 2) Automated Health Assessment (AHA) System, 3) Automated Response and Recovery (ARR) Control System, 4) developing a cyber-physical microgrid testbed to implement, test and validate the technologies. The four thrusts are described in detail next.

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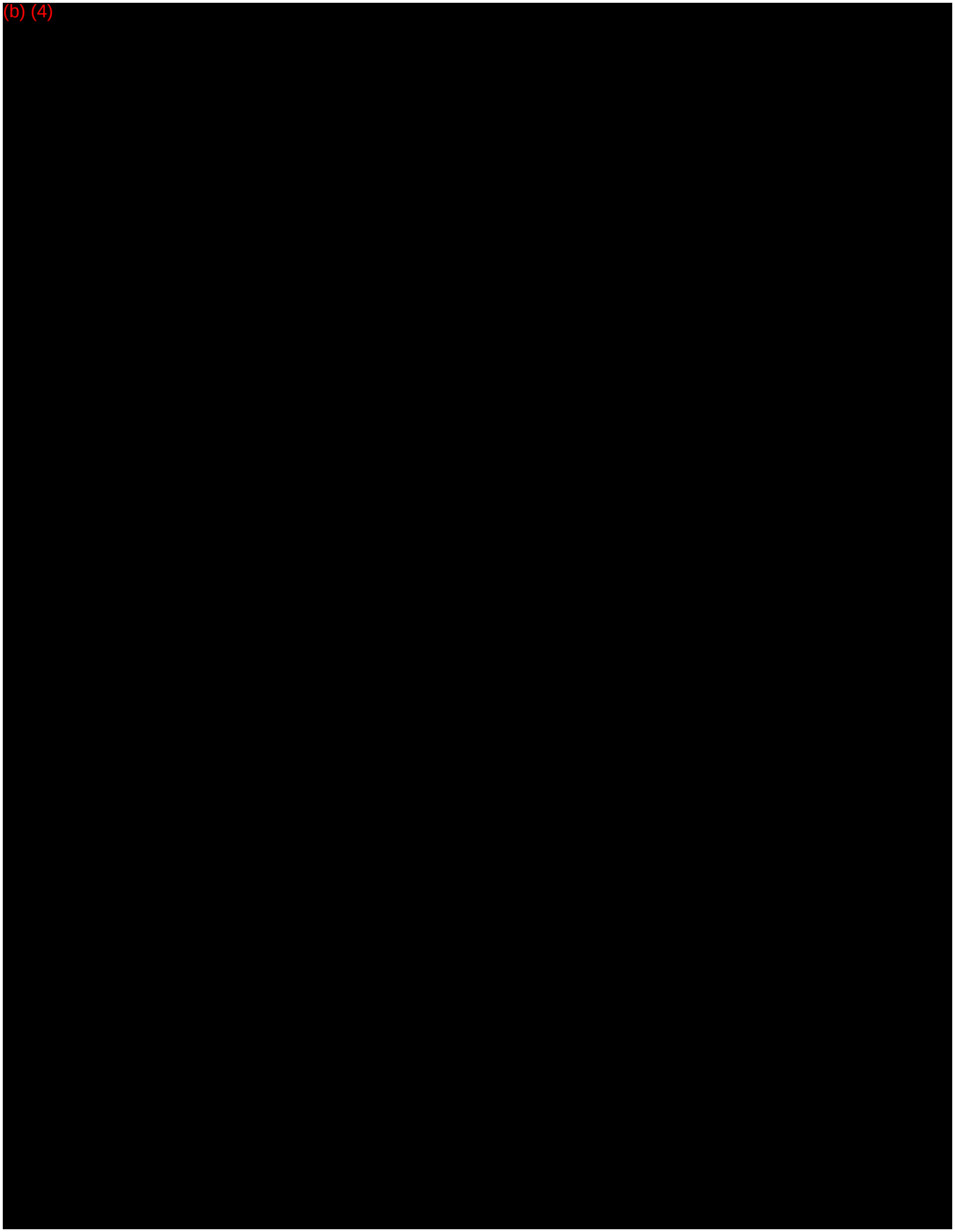

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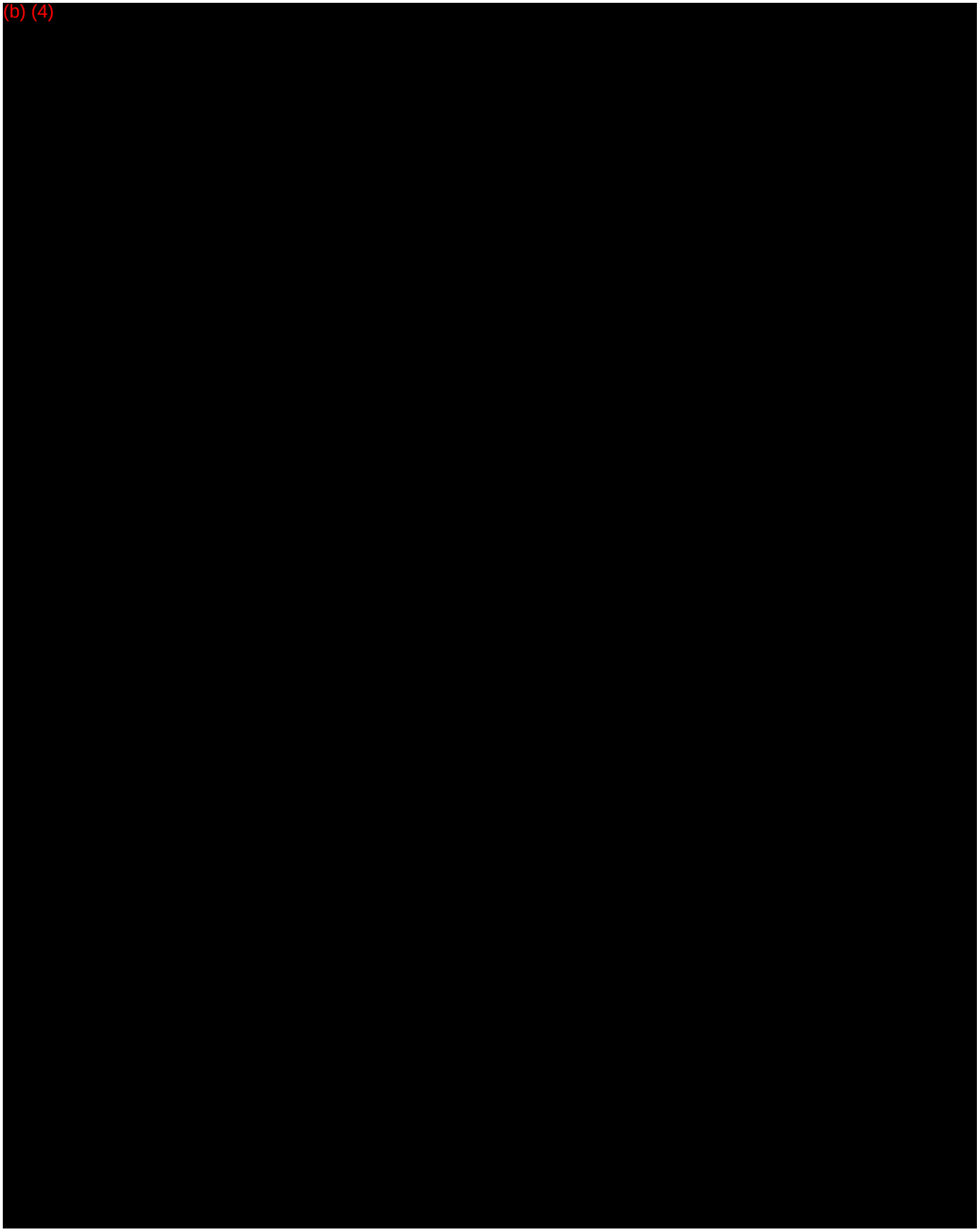

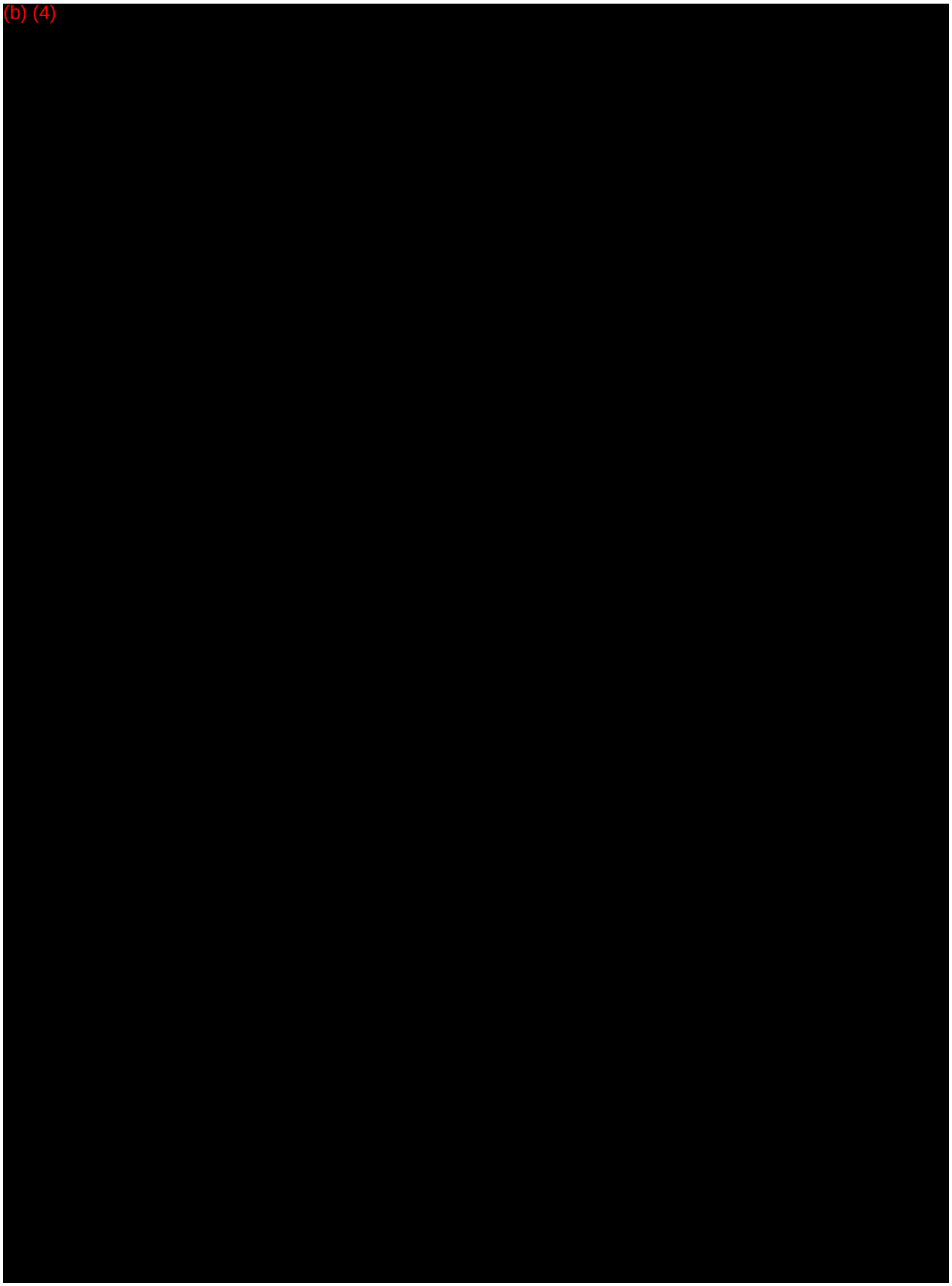
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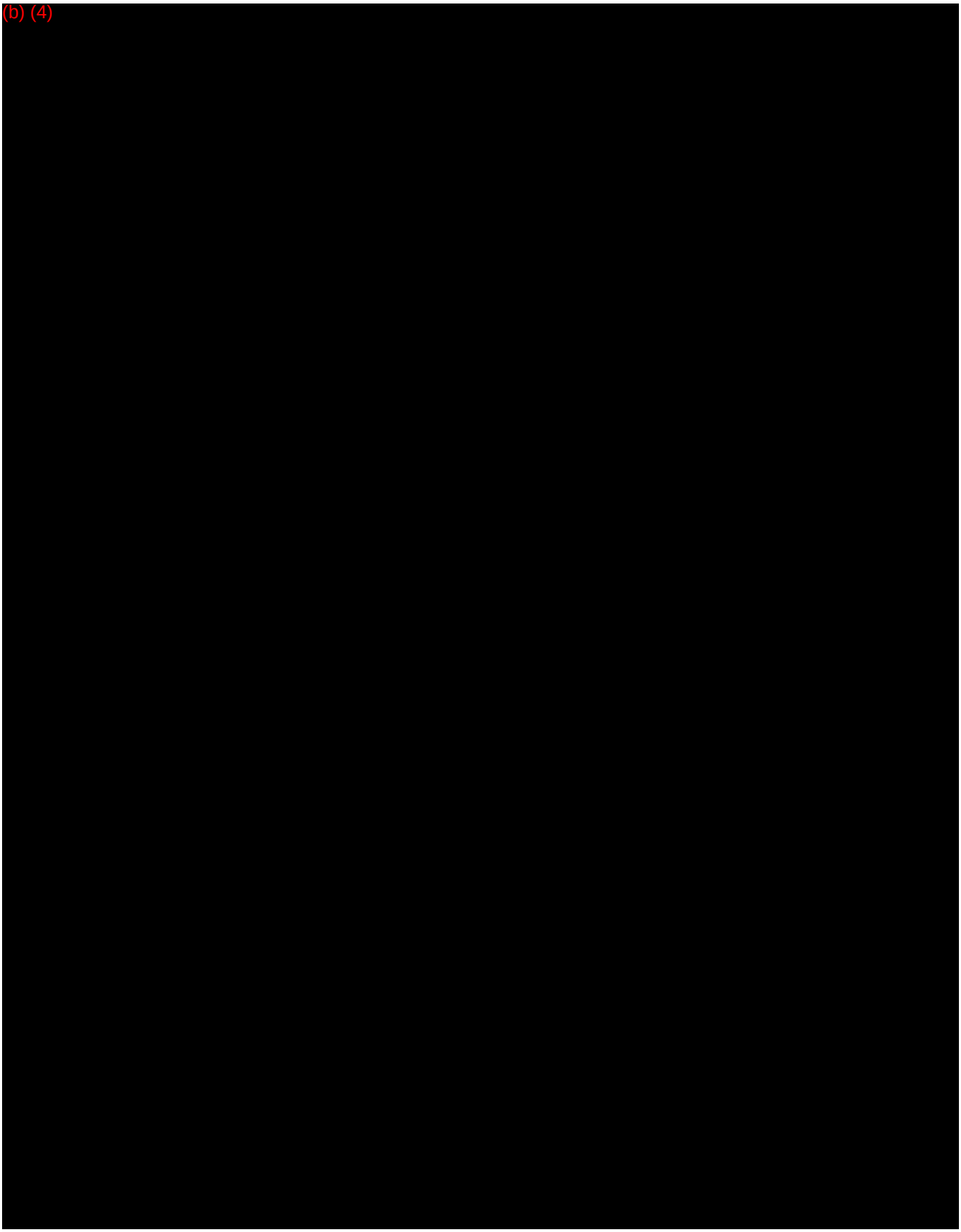

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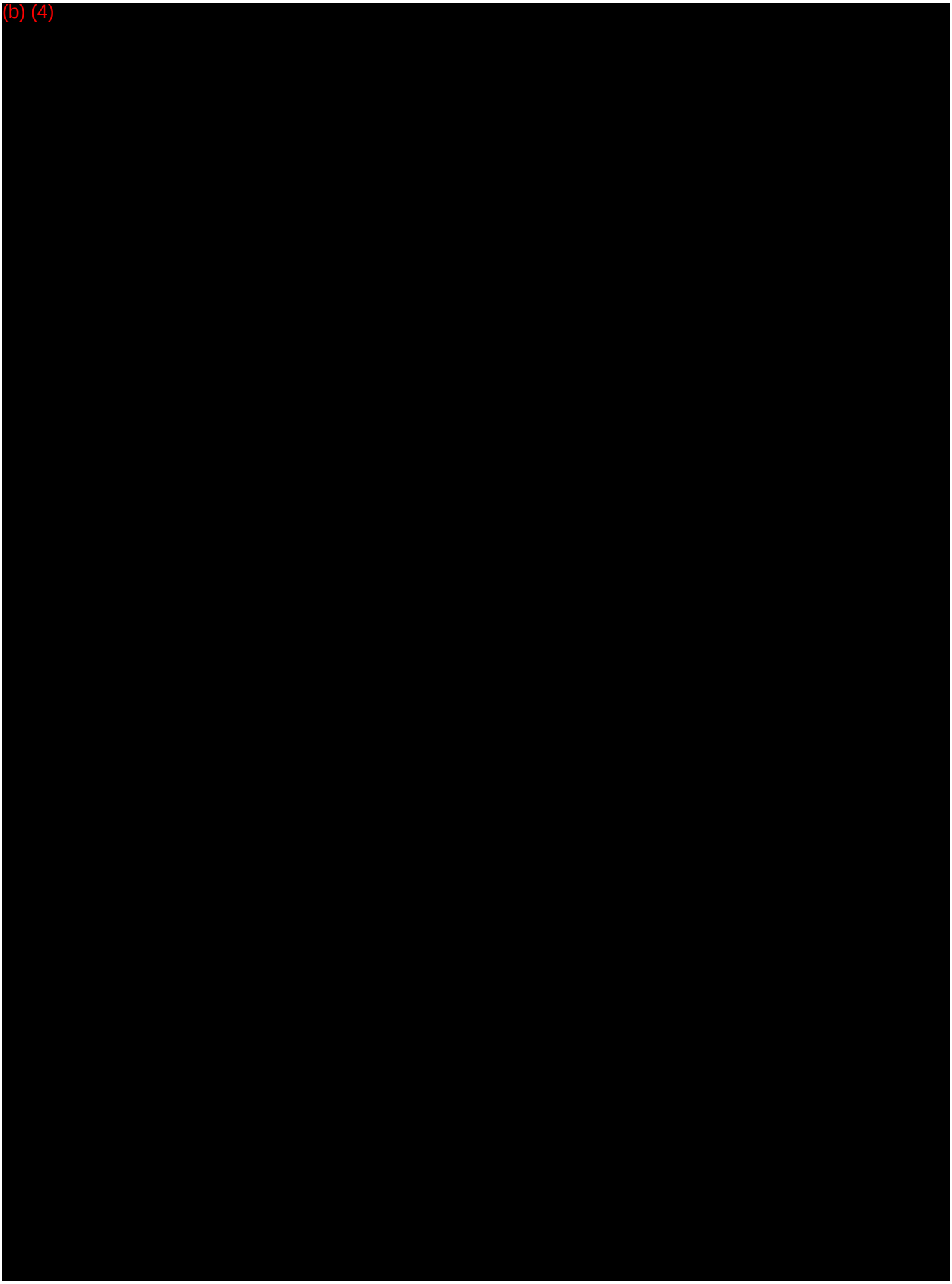

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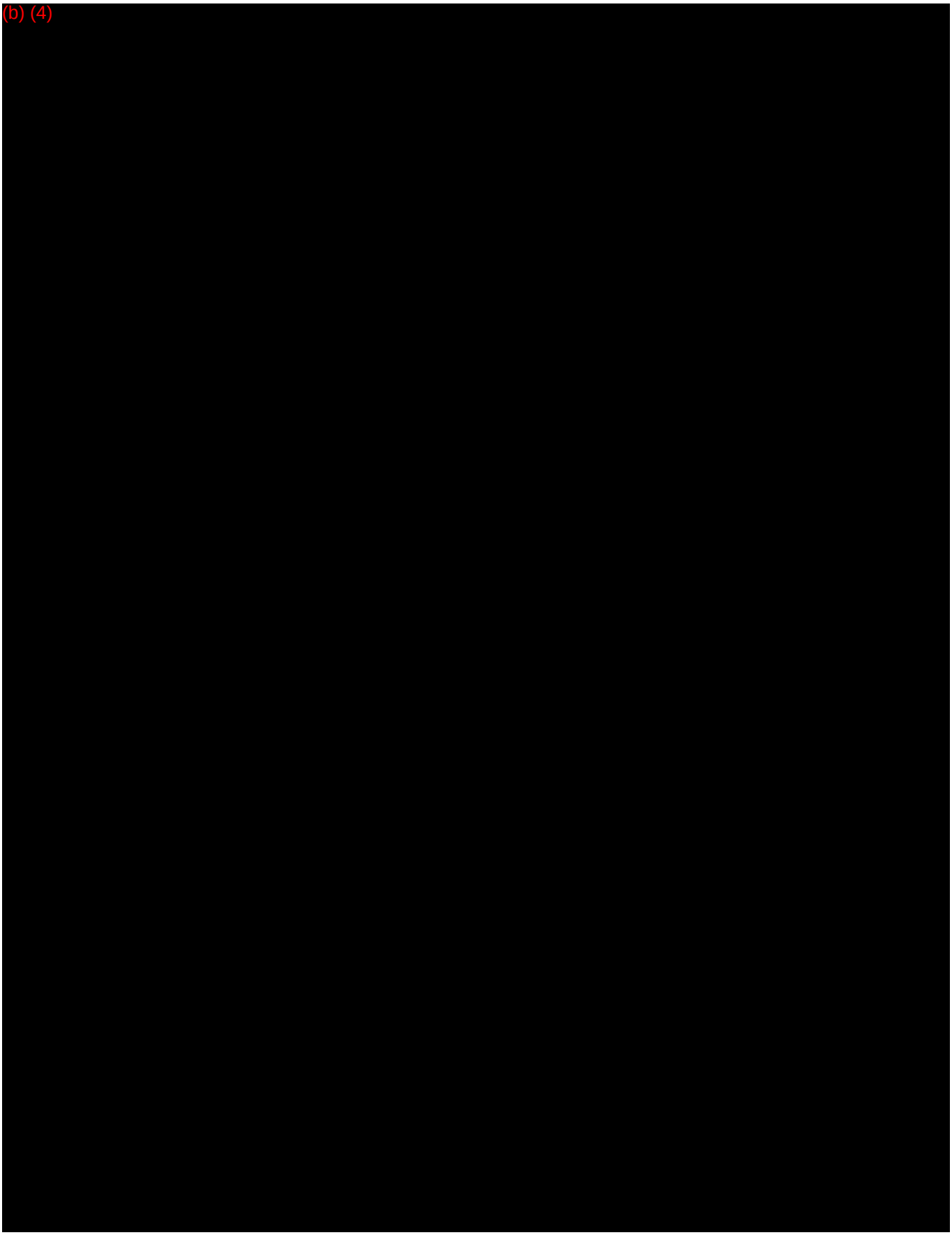

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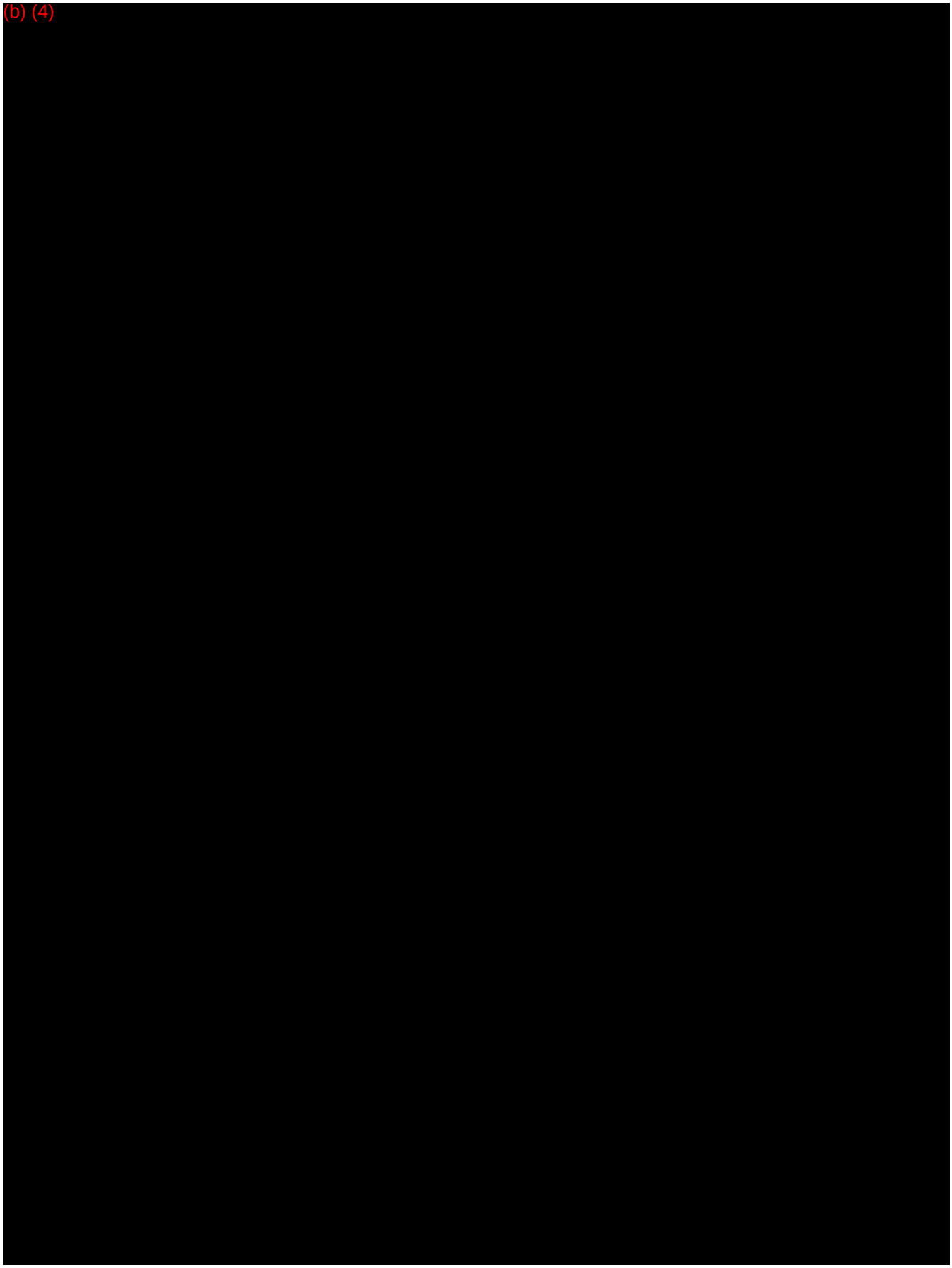

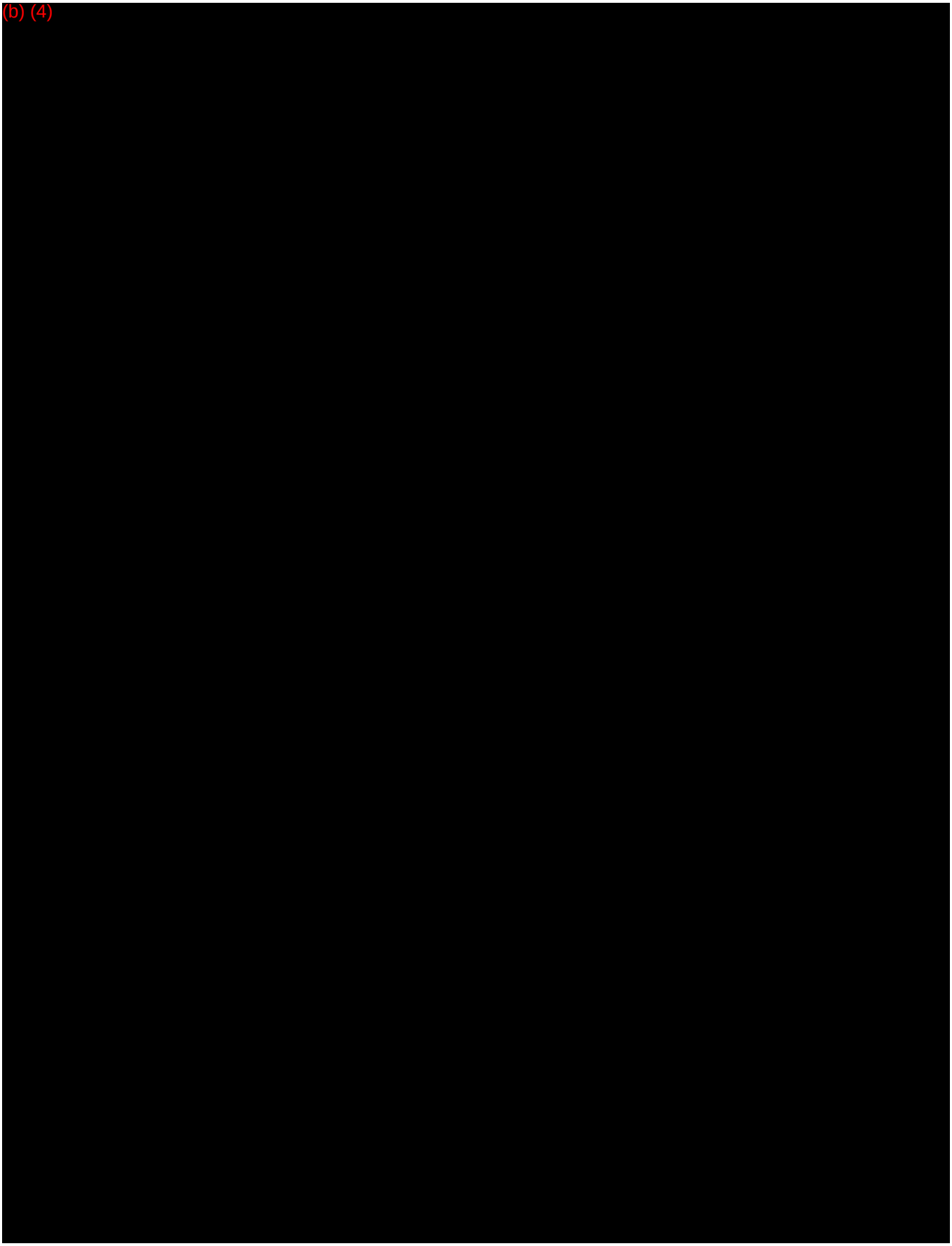
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1.4. Thrust 4: Implementation and Validation on Cyber-Physical Microgrid Testbed

An important step to bring the proposed technologies to market is to implement and test the technologies in lab environment and verify the intended application for enhancing the cyber-physical security of microgrids. (b) (4)

In this Thrust, we propose to develop a cyber-physical microgrid testbed at the department of Electrical and Computer Engineering (ECE) at the University of Utah for implementation, testing, and verification of the proposed technologies in Thrusts 1-3. (b) (4)

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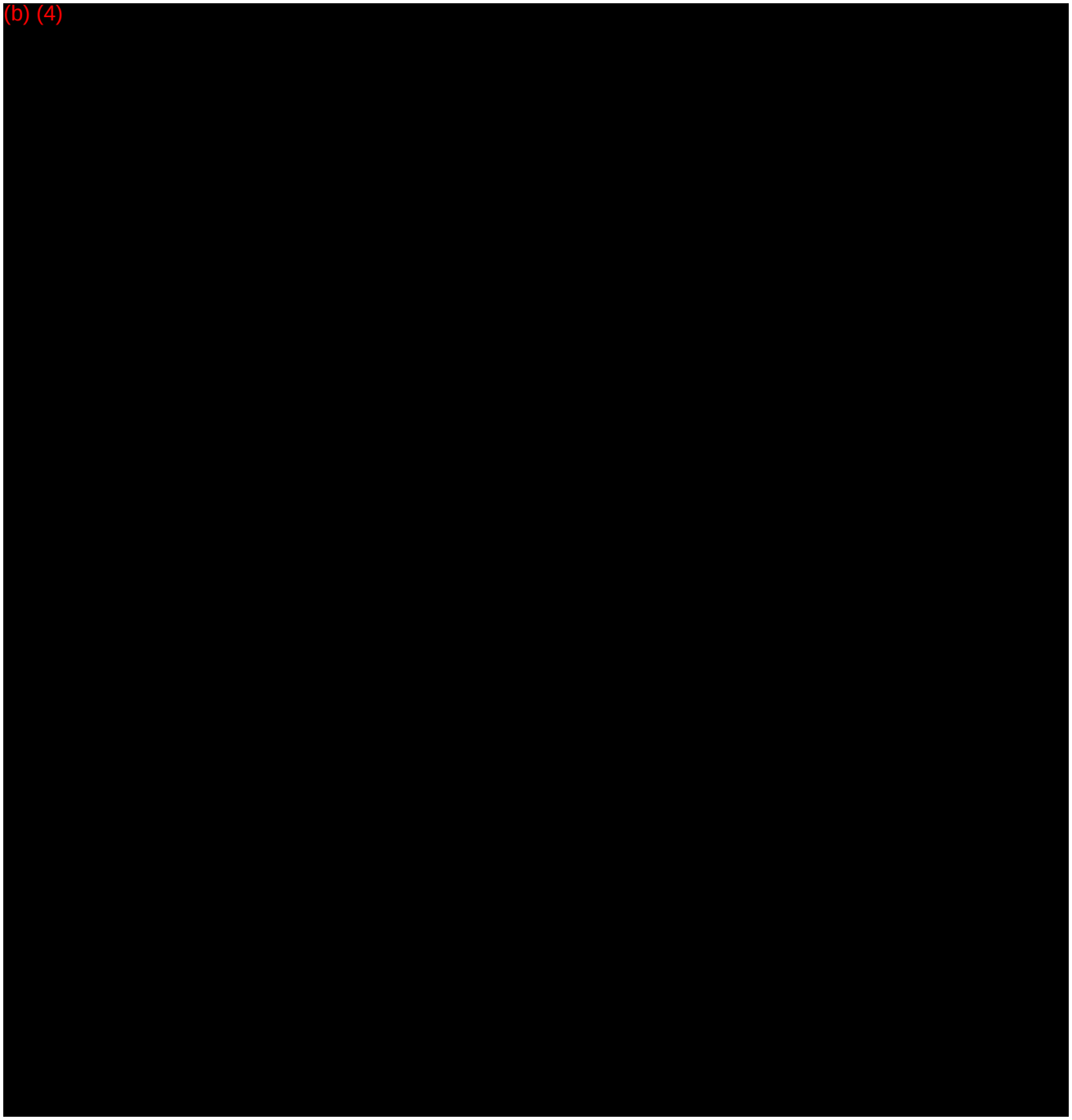

2. Technology Maturation Process

This project will implement a comprehensive lab-to-market approach for technology maturation, involving key partners from the University of Utah and Utah state agencies. The proposed technology maturation plan and the role of committed project partners are explained next.

2.1. The University of Utah Technology and Venture Commercialization Office

The University of Utah is named by the Milken Institute as **Number 1** for Best Universities for Technology Transfer in 2017 [15]. Through the strong and well-stablished Office of Technology and Venture Commercialization (TVC), the University of Utah has created over 230 companies from technologies developed at the University, most of which were launched over the past ten

years [16]. The commercialization support by TVC is a value-adding, vetting and de-risking process, which facilitates understanding inventions, determining their market fit, acting on feedback from potential customers, protecting intellectual property, creating a strong business model, identifying milestones, and executing an acceleration plan. The TVC will work with this project team to implement a lab-to-market and commercialization approach as explained next, and provide the team with *business incubator* and *incremental funding* to move the technologies developed in this project to commercialization (see letter of support).

Market Analysis and Business Strategy Development through Lean Canvas Cohort: As the first step in technology maturation after invention disclosure, TVC will work with the project team to conduct a market analysis and develop a business strategy for the technologies developed in this project. TVC facilitates this by running a Lean Canvas Cohort for market analysis and building a viable business model for commercializing the technologies developed by the project team. TVC's Lean Canvas utilizes the Lean Startup principles and is based on the Business Model Canvas used in the I-Corp programs by NSF and NIH. TVC is very experienced in organizing the Lean Canvas Cohort, which has led to many successful technology commercialization [30].

In the Lean Canvas Cohort, the project team (students, postdocs, faculties) would interview roughly 100 prospective customers and partners, and develop a creative strategy that incorporates customer needs and challenges for determining the market potential and moving the technology towards commercialization. In the Lean Canvas, an *Entrepreneurial Lead* and a *Business Mentor* will join the project team and will work together over a seven-week program to properly assess true opportunities of the technologies and develop a business strategy. The information gathered through the interviews and studies in the Lean Canvas is shown in Fig. 8, which includes identifying key partners and customer segments and create relationships and market channels for future marketing purposes. The plan would sketch a detailed cost structure and revenue stream for the technologies developed under this project.

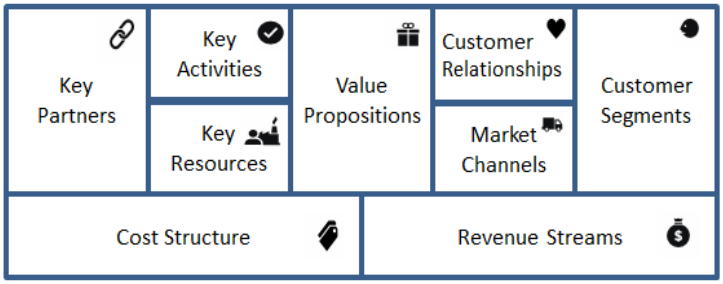

Figure 8: The Lean Canvas for Business Development

IP Protection: Once a promising business strategy is established for a technology, given the nature of the technology (algorithm, software, firmware, hardware), TVC will protect the IP by pursuing patents, copyrights, and trademarks, and would pay for the associated costs. The project team will work with the patent counsel in drafting the patent applications and responses to patent offices. TVC will protect software, and firmware developed in the project through copyrights.

Licensing and Startup Business: TVC and the project team will utilize the outcomes of Lean Canvas to identify the best commercialization strategy and determine if the sound business decision is to license to startup or an established company. Potential licensees could be also identified through the connections made during the Lean Canvas. Every license is unique in that it brings together university IP to solve a company's specific problems. TVC will work with the potential companies and the project team to reach a license agreement agreeable to all parties.

Commercialization Funding and Business Incubator: Forming a startup business is an alternative to licensing the IP to an established business. TVC offers several programs for assisting in the market research, business planning and setup of new companies and in many cases the University will establish a new company itself. TVC will provide the project team with seed funding for the technologies developed in this project. This includes the *Commercialization Engine Fund*,

as well as *the Gateway Crimson Innovation Fund* [17]. TVC would also offer a business incubator space for the project startup licensees. The incubator wraps the project team around many services, including access to legal and accounting support, educational programming, networking events, and assistance with identifying and recruiting strategic hires, board members, and mentors.

2.2. Commercialization Support by the Utah Science Technology and Research

The Utah Science Technology and Research initiative (USTAR) is established in 2006 as part of the Utah Governor's Office of Economic Development to support technology-based economic development through a diverse portfolio of funding programs and technology entrepreneurship services. USTAR is the State of Utah's technology catalyst, accelerating the growth of the innovation ecosystem from invention through product development [18]. The USTAR will support and guide the technology commercialization activities by the project team, through providing business incubators and multiple grant programs aimed at technology maturation and commercialization (see letter of support). PI Parvania's work at the Utah Smart Energy Lab is currently funded by USTAR, and he is working closely with them for maturing a microgrid load control technology.

2.3. Technology Commercialization at Idaho National Laboratory

Transferring technology to the commercial sector is a statutory responsibility for INL. INL has furthered integration of advanced cyber security and modeling concepts through both open source and commercialization processes. Sophia is an example of a recent commercialization effort that was originally beta tested to numerous industries under DOE funds, and licensed to NexDefense to commercialize. AICS also is in the process of commercialization, and has been part of the Department of Homeland Security's Transition to Practice.

3. Technology Adoption by Defense and Commercial Sectors

This project involves three major partners, Utah Governor's Office of Energy Development (OED), Utah Department of Veterans and Military Affairs (VMA), and Western Electricity Coordinating Council (WECC), who will work with the project team in order to promote the adoption of the technologies in the defense and commercial sectors (see letters of support).

Utah Governor's Office of Energy Development (OED): OED's mission is to advance energy development in Utah through industrial assistance and developing partnerships with critical energy stakeholders throughout the state, region, and nation [19]. OED will leverage these partnerships to facilitate stakeholder engagement with the project team through OED-hosted workshops, its annual Utah Energy Summit, and other regular meetings held with its partners. OED will facilitate technology adoption by the public utilities (PacifiCorp, Utah Associated Municipal Power Systems, Utah Municipal Power Agency), commercial sector (Hunt Electric, BYD/GreenCharge, Redfish Builders, Enel), and city corporations (Logan City, Moab City, Park City, and Salt Lake City). OED will also facilitate technology adoption by the defense sector through its *Military Energy Installations Collaborative* that include Hill Air Force Base, Tooele Army Depot, Dugway Proving Ground, Utah Air National Guard. In addition, OED has been collaborating on many energy topics (including the development of Regional Electric Vehicle Plan for the West) with western states (Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Wyoming). OED will leverage this regional partnership to facilitate the technology adoption over the west. PI Parvania has current partnership with OED on other projects (see letter of support).

Western Electricity Coordinating Council (WECC): WECC is a non-profit corporation, delegated by the Federal Energy Regulatory Commission (FERC) and North American Electric Reliability Corporation (NERC), to assure the reliability of electric power grid in the geographic area

that extends from Canada to Mexico and includes the provinces of Alberta and British Columbia, the northern portion of Baja California, Mexico, and all or portions of the 14 Western states in between (the Western Interconnection). WECC (based in Salt Lake City) will leverage its broad membership body (local and regional electric utilities, to state regulators) to facilitate communication and partnership between the project team and the western electric utility sector (see letter of support). PI Parvania has been working with WECC on other regional studies (see e.g., [31]).

The Utah Department of Veterans and Military Affairs (VMA): VMA will facilitate partnership with the Utah military bases to promote and adopt the technology throughout the project. In addition, through the established Utah Veteran Owned Business Partnership (UVOBP), the VMA will connect veteran entrepreneurs and business owners with the project team [20]. The UVOBP is a consortium of agencies dedicated to helping veterans and service members have success in business. VMA will also support the project team to promote the technologies and connect with the veteran business owners at its annual Utah Veteran Business Conference (see letter of support).

4. Workforce/Professional Development Plan

This project will execute multiple activities for workforce and professional development, which include hands-on microgrid training, Entrepreneurship training, Professional Development and Career Preparation, and organizing Power and Energy Career Expos. This project will target to engage the reserve Navy officers of the University of Utah NROTC in the activities. We anticipate that the technologies and partnerships developed through this project would lead in many new microgrid and energy resilience projects (especially by the military partners), creating new jobs in the local and regional energy industry. The UVOBP will connect the project team with the veteran entrepreneurs and business owners to participate in the commercialization activities that would lead to workforce and business development in the veteran community (see letters of support).

4.1. Hands-on Microgrid Testbed Training

As mentioned in Section 1.4, PI Parvania will leverage the proposed cyber-physical microgrid testbed to create a hands-on microgrid lab at the ECE department at the University of Utah. The ECE department is committed to provide the required space and furniture to house the lab in the Merrill Engineering Building in the University of Utah campus, which would create opportunity for up to 20 students to take the lab course each semester and learn hands-on training on microgrid operation (see letter of commitment).

4.2. Hands-on Training for the Naval Reserve Officers Training Corps (NROTC) Unit

The project team will work with the University of Utah's NROTC unit to involve the reserve Navy officers in the program. Specifically, we will seek to encourage the reserve officers to specialize in the power engineering program at the ECE department and take the hands-on Microgrid training lab. In addition, we will define special summer courses and projects on the topics related to power grid resilience and microgrid. We will also leverage the partnerships made in this project to provide opportunities for the reserve officers to take summer internships and gain real-world experience working in the power industry. Senior Personnel Dr. Angela Rasmussen (the ECE undergraduate adviser) will lead this effort to engage the reserve officers in the program.

4.3. Entrepreneurship Training

The Lassonde Entrepreneurship Institute at the University of Utah will partner with the project team to provide hands-on entrepreneurship training for the students and postdocs involved in the project (see letter of partnership). Through this partnership, the students will take Business and Entrepreneurship courses offered through the University of Utah's Engineering Entrepreneurship Certificate, and will participate in the Foundry course offered by the Lassonde Institute. The Foundry is a hands-on training experience for the students to grow their business idea and potential with a group of peers, instructors and local Entrepreneurs. Senior Personnel Dr. Angela Rasmussen will lead this effort to guide students taking the courses and training in Entrepreneurship.

4.4. Power and Energy Career Expo

The University of Utah's Career and Professional Development Center (CPDC) will partner with the project team to put on a special *Power and Energy Career Expo* through the second and third years of the project (see letter of support). The expo will provide the students involved in the project and the other students interested in the power and energy sectors with opportunities to meet recruiters and staff from leading regional employers, demonstrate their skill sets and technical focus, learn about current job opportunities, and explore career options in the industry. At the expo, employers will set up company tables, and hold one-on-one conversations with interested students. This will be a customized smaller scale format of a traditional job fair, in which recruiters get to have a personal interaction with many students, share important aspects of their company, and discuss next steps with their preferred candidates.

The Utah Governor's Office of Energy Development, Western Electricity Coordinating Council, and the Utah Department of VMA will work with the project team and CPDC to promote the expo at a regional scale and attract the defense and commercial sector from all over the Western states (see letters of support). PI Parvania and CPDC will leverage their network and partnerships to invite students from universities over the state and region to attend the expo. The CPDC has a well-established partnership with the University's *Veterans Support Center* [22] and 1 FTE dedicated to working with job seeking veterans on campus. This existing staff will ensure that the expo will be developed with campus veterans in mind and advertised effectively to this community.

In addition to the Expo, the CPDC will work with the project team to hold the *Industry-Student Luncheon and Poster Session at the Western Power Grid Resilience Conference*, which provides opportunity to present their research and interact with the military and commercial sector.

4.5. Professional Development and Career Preparation

In the weeks leading up to the expo, CPDC career coaches will provide multiple in-class or group trainings to the students on the topics of: *1) Employer Research*: Teaching students how to research the employers who will be at the expo to identify employment opportunities and gain an understanding of the company's business model, culture, recruiting practices, and response to industry trends. *2) Resume Development*: Teaching students about the basics of a strong STEM-resume and providing constructive feedback to students who bring their resume to be reviewed. *3) Pitch Training*: Helping students develop a concise and compelling pitch about their experience and technical interests. This is critical to having a successful conversation with recruiters and making a lasting impression. *4) Dress and Appearance Training*: Helping students understand that their personal appearance counts and it is important to attend such events in professional dress.

5. Future Naval Relevance

Although microgrids are developed as a solution to enhance the resilience of power grid, their current design is structurally vulnerable to various cyber-physical threats. Fortunately, the development of controllers and application for microgrid are still at their infancy, and the burden of dealing with legacy technology is still very low. This, in turn, provides an unprecedented opportunity to coordinate the development of microgrid-based resilience strategies with that of appropriate security solutions. The technologies proposed in this project would significantly enhance the cyber-physical resilience of microgrids, by developing the next generation of continuous-time microgrid controllers with built-in cyber-physical resilience solutions. We believe that the development of our proposed cyber-physical resilient microgrid technology would considerably enhance their reliability, and therefor would increase their adoption in Navy.

6. Project Schedule and Milestones

This project includes four technical thrusts with 10 major tasks that will be conducted by the project team at University of Utah (UU), and Idaho National Lab (INL). The project schedule is provided in Table 1, where the completion of proposed tasks mark the milestones of the project.

7. Reports

The PI will prepare and submit annual and final technical and financial progress reports to the program officer. The PI will also report any publication and presentation that would be produced

throughout the project. In addition, this project will organize two Western Power Grid Resilience Conference and two Power and Energy Careers Expo in the second and third years of the project. The outcomes of the events, in terms of lessons learned, partnerships, and workforce developments will be reported. The team will also prepare and submit a final report on the best practices of commercialization and workforce development activities conducted throughout the project.

8. Management Approach

The University of Utah (UU) will lead this project as the prime recipient with multiple partners committed to advance the project tasks. The role of partners is shown in Fig. 8 and explained next.

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9. Project Team Qualification, Prior Experience, and Responsibility

The University of Utah is a nationally-recognized R1 university with an excellent track record of integrity, business ethics and conducting high quality cutting-edge research. The University of Utah has skilled staff for accounting and operational controls and is eligible to receive this award under applicable laws and regulations. The project team at the University of Utah and INL are world-renown researchers on cyber-physical power grid resilience, microgrid control, and network security and have successfully completed and are currently working on multiple projects funded by federal agencies such as DOE, DoD, DHS, NASA and NSF (please see current and pending projects). The project team has ensured access to all the required resources and support to successfully conduct this project (see letters of support). In addition, both Utah Smart Energy Lab, and INL has been active and successful in pursing technology commercialization and workforce development. The Utah Smart Energy Lab has recently filed a U.S. patent on continuous-time power grids control [11], (b) (4) [redacted] Please see the CVs for more information on project team experiences.

10. Facilities & Equipment

The *Utah Smart Energy Lab* at the Department of Electrical and Computer Engineering (ECE) maintains a computational network including several desktop computers and laptops that are equipped with the necessary software to model, analyze and solve the control problems in the context of this project. This project proposes to develop a cyber-physical microgrid testbed at the department of Electrical and Computer Engineering (ECE) at the University of Utah for implementation, testing, and verification of the proposed technologies (details in Section 1.4). The high performance computing cluster and storage systems required for the testbed will be provided by the state-of-the-art facilities at the *Center for High Performance Computing* (CHPC) at the University of Utah (see letter of partnership). (b) (4) [redacted]

INL Resilience Control Systems Research Laboratory: The resilient control systems research laboratory at INL possesses multiple ICS technologies and high fidelity emulations that allow for time-coupled testing of control and power dynamics. Direct injection of cyber and physical failures is allowed through this isolated network to evaluate the threat resilience of developed algorithms for anomaly detection, response and mitigation.

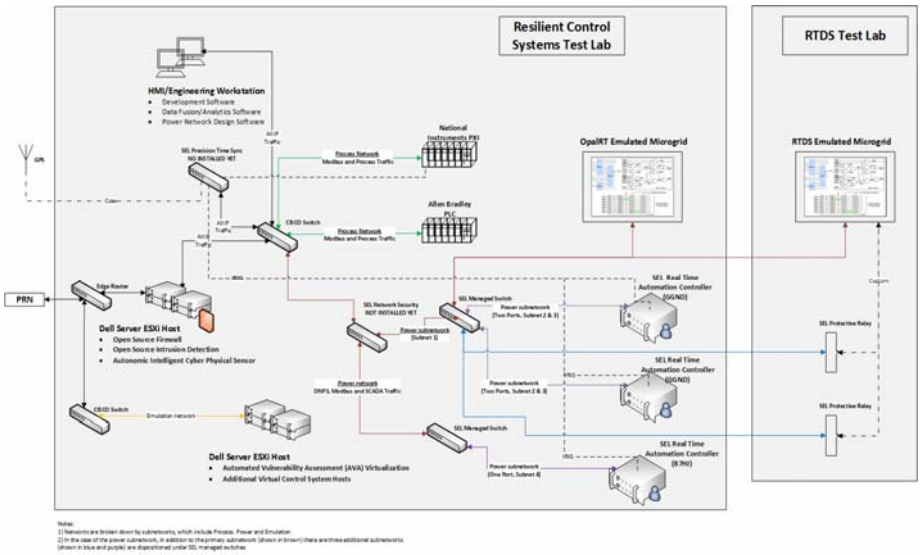

Fig. 9: Resilient Control Systems Testbed at INL. More info at: https://icis.inl.gov